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* Chart VIII is published only during snow season.

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MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

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METHODS OF EVALUATING ULTRA-VIOLET SOLAR RADIATION IN ABSOLUTE UNITS

By W. W. COBLENTZ [1]

At the Oxford Meeting (Sept. 12–15, 1936) of the International Commission on Solar Radiation, during the discussion of the use of photoelectric cells in meteorology, the question was raised whether there is not some method of standardizing photoelectric radiometers so that ultra-violet solar radiation intensities can be measured in absolute units, instead of on the arbitrary scale now used. The following is a somewhat elaborated presentation of information given by the writer in his impromptu discussion of this question, at this meeting:

In recent years it has been definitely established that the radiation in the spectral band of ultra-violet, of wave lengths shorter than about 3132A, in artificial sources and in sunlight, has a specific effect in healing rickets; and by inference it seems to be assumed that these ultra-violet rays have a beneficial effect upon general health conditions.

Whether the latter broad generalization is justified remains to be determined. Nevertheless it is impressive to note how people everywhere, in all walks of life, have come to believe in the beneficent effects of sunlight. Hence, it is the opinion of the writer that meteorological observatories of the various countries would perform a useful service by including measurements of the intensity of the spectral band of ultra-violet radiation of 3132A and shorter wave lengths in their observations of solar radiation.

The wave length 3132A is mentioned specifically because it is an intense emission line in the quartz-mercury arc lamp, in common use, which for all practical purposes may be considered the long-wave-length end point in erythemal and antirachitic action. (See figure 1 (320mμ= 3200A).)

METHODS OF EVALUATING ULTRA-VIOLET SOLAR RADIATION

In place of the arbitrary scale, now in use in measuring ultra-violet solar intensities with cadmium photoelectric cells and filters, it is desirable to obtain the measurements in absolute value, independent of the kind of radiometer and filters used.

Recently the writer, in collaboration with R. Stair, (1) (3), has worked out two entirely different methods, which give closely concordant results in evaluating ultra-violet radiation of short wave lengths (shorter than 3132A in artificial sources and in sunlight) in absolute value for use in medicine (4).

These methods are useful also to meteorologists. Depending upon the judgment of the observer, additional refinements can be made in the calculations, if warranted by the accuracy of the measurements of the ultra-violet intensities, which, owing to great variations in atmospheric transparency, are subject to far greater variations than the integrated total solar radiation intensities measured even during the clearest weather. The reason that these great variations in ultra-violet intensities are not observed in the measurements of total intensities is because, at the most, the integrated ultra-violet radiation of wave lengths shorter than 3132A is only about 75 parts in 100,000 of the total solar intensity measured.

The first method designed by us employs a differential thermopile and filters (1). This method requires an accurate knowledge of (*a*) the ultra-violet spectral transmission of the glass filters, and (*b*) of the distribution of energy

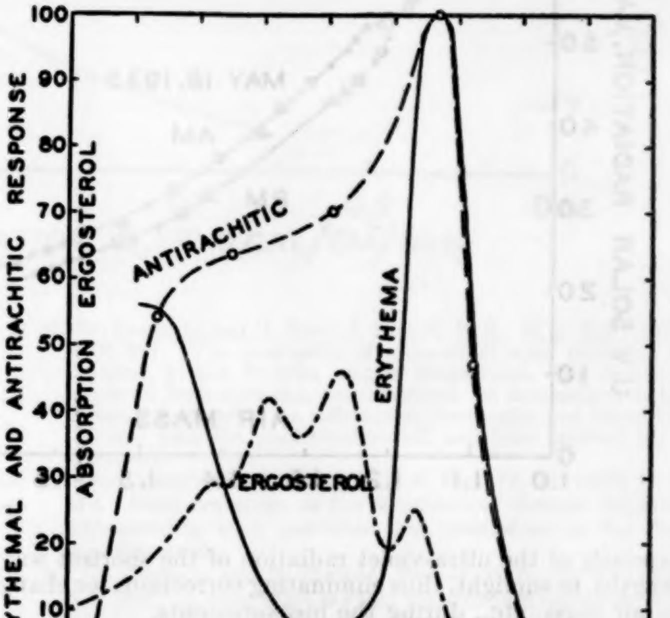

FIGURE 1.

within and adjacent to the spectral band of radiation evaluated. In sunlight this spectral energy distribution, in relative value, is determined by means of a Ti- or Cd-photoelectric cell and suitable filters. The evaluation in absolute units is accomplished by calibrating the combination thermopile-galvanometer radiometer against a standard of thermal radiation (5).

The second method employs a Ti- or Cd-photoelectric cell and glass filters (2). The photoelectric cell is used with a balanced amplifier (Wheatstone bridge) and a microammeter. The novelty in the device is a means of determining the sensitivity of the amplifier at any moment, which is important since the sensitivity varies slightly

[1] Member, Council on Physical Therapy of the Amer. Med. Association; Member International Commission on Solar Radiation, of the Internat. Union Geodesy and Geophysics.

with the temperature, the age of the dry batteries, and the voltage on the filament of the amplifier tube. This method requires a knowledge (*a*) of the ultra-violet spectral transmission of the filters, (*b*) of the spectral response of the photoelectric cell and (*c*) of the distribution of energy within and adjacent to the spectral band of radiation that is to be evaluated. The evaluation in absolute units is obtained by calibrating the photoelectric cell-microammeter radiometer against a standard of ultra-violet radiation, consisting of a special quartz-mercury arc lamp (**6**).

The second method makes it possible to determine simultaneously, with one instrument, both the *spectral quality* (the spectral energy distribution) and the *total* tensity measurement is made) it is possible to evaluate the energy in a spectral band, independently of the filter and the photoelectric cell.

Fortunately, photoelectric cells and filters are now obtainable that remain constant. The fact that the spectral response is not the same for all cells of the same type (Ti or Cd) is of no consequence. As a matter of fact, in order to test the applicability of his photoelectric cell and filter method, the writer selected two Ti-photoelectric cells in which the response, in the long wave lengths, terminated in the region of 3300A and 3500A, respectively. The main question is the constancy of the photoelectric response over a period of years. The Ti-cells used extensively by the writer have remained constant for over 5 years. But even this question has now been eliminated

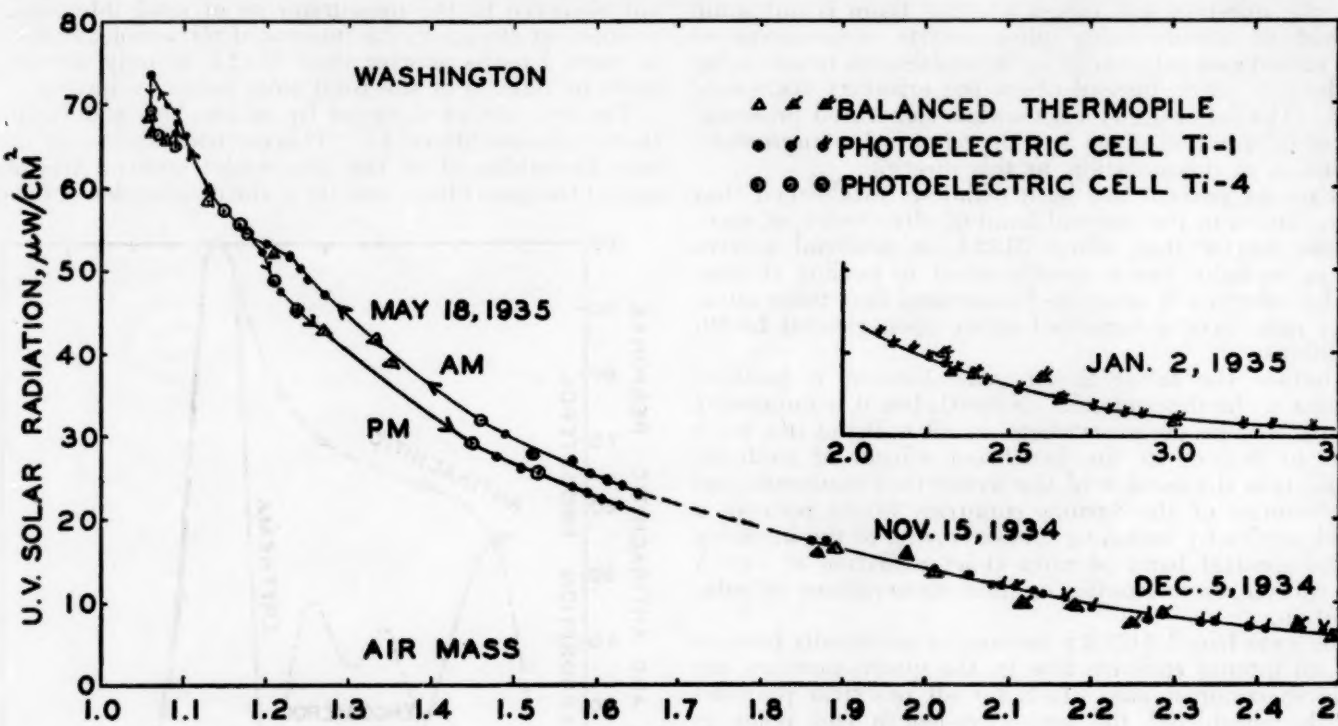

Figure 2.

intensity of the ultra-violet radiation of the shortest wave lengths, in sunlight, thus eliminating corrections for change in air mass, etc., during the measurements.

By means of either of these methods a measurement is obtained, in absolute value, of the radiation in the spectral band of wave lengths shorter than about 3132A, independent of the kind of radiometer.

A typical example of what has been accomplished in evaluating ultra-violet solar radiation in absolute units at different seasons of the year is illustrated in figure 2. The measurements made on May 18, 1935, are interesting because the sky was cloudless throughout the day and only an experienced observer could note a change in turbidity. Nevertheless the photoelectric cell recorded a definite change in transparency of the atmosphere.

It is impractical to employ a large group of filters, having exactly the same spectral transmissions, for use in different observatories. Moreover, it is undesirable to have the measurements in terms of an arbitrary filter and photoelectric cell or thermopile. By knowing (*a*) the spectral transmission of the filter, (*b*) the spectral response of the photoelectric cell, and (*c*) the spectral-energy distribution of the source (which in the case of sunlight is determined at the time the integrated ultra-violet intensity measurement is made)

by the use of a standard of ultra-violet radiation (**6**) for calibrating the apparatus in absolute value.

By cooperating with qualified physicists in their national standardizing institutes, meteorologists of various countries should encounter no difficulties in making these measurements on a uniform (absolute) scale, at least on the clearest days. The worth-whileness of securing a continuous record, during all sorts of weather conditions, remains to be determined.

Since present-day meteorologists are occupied primarily in making measurements of the total solar radiation intensity, in figure 3 is shown the intensity of ultra-violet radiation (u. v. Q), of wave lengths shorter than 3132A, relative to the total solar radiation intensity (Q) in g cals/cm ²/min, on a very clear day in June. As shown in figure 2, at the noon hour, during the clearest days in winter, the ultra-violet intensity in Washington, D. C., is only about one-tenth the value observed under similar conditions at the noon hour in summer.

Detailed descriptions of the experimental procedure and technical details of the calculations involved in the above-described methods of evaluating ultra-violet radiation in absolute units are given in the above-cited papers published in the Journal of Research of the National Bureau

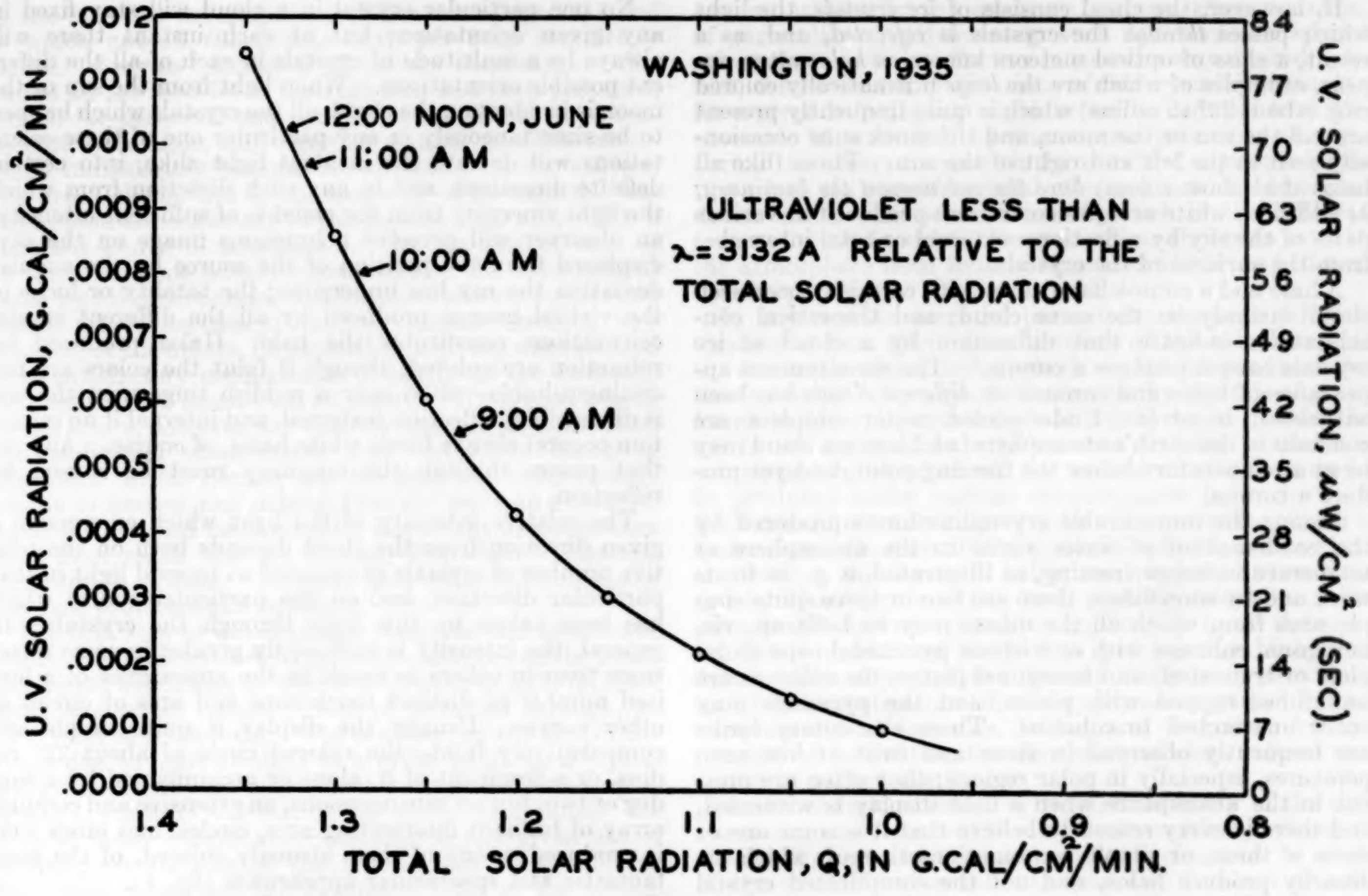

FIGURE 3.

of Standards, Washington, D. C.; and abstracts of this procedure are published in recent issues of Strahlentherapie and of the Annales d'Actinologie.

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(1) W. W. Coblentz, R. Stair, and J. M. Hogue. Bur. Stds. J. Research, *7*, 723 (1931), R. P. 370. A description is given of a balanced ("differential") thermocouple and filter method of ultra-violet radiometry, with practical applications.

(2) W. W. Coblentz, R. Stair, and J. M. Hogue, B. S. J. Res., *8*, 759 (1932), R. P. 450. This paper gives a description of tests made with a balanced thermocouple and filter radiometer as a standard ultra-violet dosage intensity meter.

(3) W. W. Coblentz and R. Stair. Jr. Res. Nat. Bur. Stds., *12*, 231, (1934), R. P. 647. A description is given of the construction and performance of a portable ultra-violet meter, consisting of a balanced amplifier (in the form of a Wheatstone bridge) photoelectric cell and microammeter. A novelty in this device is a means of unbalancing the bridge and thereby testing its sensitivity at any moment—an important item apparently overlooked by recent experimenters in this field.

(4) W. W. Coblentz and R. Stair, J. Res. N. B. S., *16*, p. 315 (1936), R. P. 877. The evaluation of ultra-violet solar radiation at sea-level, in the Tropics, and in midlatitude, also measurements at high altitudes, are described. A comparison of the measurements with the differential thermopile and filters (1), (2), and with the photoelectric cell and filter method (3) is described.

(5) W. W. Coblentz and R. Stair, B. S. J. Res., *11*, 79 (1933) R. P. 578. Data are given on the standards of thermal radiation first issued in 1914, and since then maintained by the Nat. Bur. Standards.

(6) W. W. Coblentz and R. Stair, J. Res. N. B. S., *16*, 83 (1936) R. P. 858. A description is given of a standard source of ultraviolet radiation for calibrating photoelectric dosage intensity meters. In the first-described model a quartz-mercury arc, with one electrode of mercury, was used. In the most recent set-up the source is a newly developed quartz-mercury vapor lamp in which both electrodes are of activated metal and in which there is only a globule of mercury which is completely vaporized. Hence there is no change in density of the mercury vapor with change in temperature.

THE GEOMETRICAL THEORY OF HALOS—I

By EDGAR W. WOOLARD

[Weather Bureau, Washington, D. C., November 1936]

Sundogs or mock suns, and colored rings around the sun or the moon, are more or less familiar to everyone; they have been regarded popularly as indications of the coming weather ever since the time of the Chaldeans. These phenomena may be divided into two general classes, on the basis of their physical origin:

First, when light from the sun or the moon shines through a thin cloud of *water droplets* in the earth's atmosphere, the light which passes *between* the droplets is *diffracted;* and, as a result, under appropriate conditions the luminary is observed to be surrounded by one or more series of partial or complete rings, usually small—only a few degrees in radius—and more or less distinctly colored. The colors are arranged in prismatic sequence, *with the red farthest from the source of light.* This optical phenomenon is known to the meteorologist as a *corona*—lunar or solar, as the case may be.

If, however, the cloud consists of *ice crystals*, the light which passes *through* the crystals is *refracted;* and, as a result, a class of optical meteors known as *halos* often appear, examples of which are the *large* prismatically colored ring (about 22° in radius) which is quite frequently present around the sun or the moon, and the mock suns occasionally seen to the left and right of the sun. These (like all halos that show colors) *have the red nearest the luminary;* in addition, white arcs are sometimes produced in various parts of the sky by reflection—external or total internal—from the surfaces of the crystals.

A halo and a corona have never with certainty been seen simultaneously on the same cloud; and theoretical considerations indicate that diffraction by a cloud of ice crystals cannot produce a corona.[1] The simultaneous appearance of halos and coronas on *different clouds* has been witnessed, however. Under-cooled water droplets are common in the earth's atmosphere; and hence a cloud may be at a temperature below the freezing point, and yet produce a corona.

Among the innumerable crystalline forms produced by the condensation of water vapor in the atmosphere at temperatures below freezing, as illustrated, e. g., in frostwork and by snowflakes, there are two or three quite simple ones from which all the others may be built up, viz, hexagonal columns with or without pyramidal caps (complete or truncated) and hexagonal plates; the columns are sometimes capped with plates, and the pyramids may occur unattached to columns. These elementary forms are frequently observed in snow and frost at low temperatures, especially in polar regions; they often are present in the atmosphere when a halo display is witnessed, and there is every reason to believe that it is some one or more of them, or simple combinations thereof, which ordinarily produce halos, and not the complicated crystal groups and patterns shown in general by snowflakes—in fact, the majority of authenticated halos do not require anything more complicated than a simple hexagonal right prism (column or plate). Some of the finest halo displays have occurred with a cloudless sky, at times when the atmosphere down to the ground was filled with falling ice crystals, the exact forms of which could then be observed. Under such conditions, halos are sometimes produced by artificial lights.[2]

Although it was suggested by Mariotte as early as 1686 that halos are due to the refraction and reflection of light by ice crystals floating in the atmosphere, this explanation was long held in doubt. However, the increasing number of instances (especially in high latitudes) in which the whole atmosphere was filled with minute spiculae and crystals of ice at the same times that sundogs and halos were visible, eventually forced its truth on everyone. As these minute ice crystals fall slowly through the atmosphere, they have a tendency to assume certain definite orientations determined by the resistance of the air; but of course they continually oscillate about the equilibrium positions to a greater or less extent, and if the air is turbulent they lie largely at random. Parallel light incident on a crystal from a given direction will be deviated through refraction or reflection by an amount and in a direction that depend on the form and orientation of the crystal; and because of the multiplicity of crystal faces, different portions of the incident light will leave the crystal in several different directions.

[1] G. C. Simpson, *Quar. Jour. Roy. Met. Soc.*, 38: 291-301, 1912; S. Fujiwhara and H. Nakano, *Jour. Met. Soc. Jap.*, June 1920.

[2] See, e. g., B. W. Currie, Ice Crystals and Halo Phenomena, MON. WEATHER REVIEW 63: 57-58, 1935.

No one particular crystal in a cloud will stay fixed in any given orientation; but at each instant there will always be a multitude of crystals in each of all the different possible orientations. When light from the sun or the moon is incident on the cloud, all the crystals which happen to be simultaneously in any particular one of these orientations will deviate the incident light alike, into certain definite directions, and in any such direction from which the light emerging from the cloud is of sufficient intensity, an observer will perceive a luminous image on the sky, displaced from the position of the source by the angular deviation the ray has undergone; the totality or locus of the virtual images produced by all the different crystal orientations constitutes the halo. Halos produced by refraction are colored, though if faint the colors are not distinguishable—often only a reddish tinge next the sun is discernible; reflection (external, and internal if no refraction occurs) always forms white halos, of course. Any arc that passes through the luminary must be caused by reflection.

The relative intensity of the light which emerges in a given direction from the cloud depends both on the relative number of crystals so oriented as to send light in that particular direction, and on the particular course which has been taken by this light through the crystals. In general, the intensity is sufficiently greater in some directions than in others to result in the appearance of a limited number of distinct mock suns and arcs of circles or other curves. Usually the display is quite simple and comparatively faint—the colored circle of about 22° radius, or a fragment of it, alone or accompanied by a sundog or two; but on rare occasions, an extensive and complex array of brilliant intersecting arcs, circles, and mock suns is produced, many of them strongly colored, of the most fantastic and spectacular appearance (fig. 1).

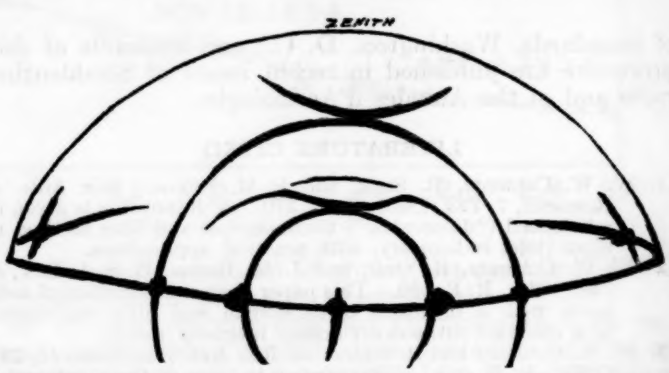


FIGURE 1.—Halo observed at Boulder, Colo., January 10, 1918, showing sun-pillar, parhelic circle, 22° halo, 46° halo, 22° parhelia, 46° parhelia, upper tangent arc of the 22° halo, Parry arc, circumzenithal arc, parhelia of 120°, paranthelic arcs; solar altitude, 20°. Drawn by Edgar W. Woolard. (MON. WEATHER REV., 48: 331, 1920.)

Individual displays differ widely among themselves in respect to the number, forms, brilliance, and coloring of the arcs. The particular arcs that appear, and their brilliance and exact form, depend on the altitude of the luminary above the horizon; on the abundance and predominating geometric forms of the crystals; and on the windiness of the atmosphere. Some of them are quite common and have been known since remote antiquity; others have been seen only a few times. Lunar halos are almost invariably simple, faint, and colored only slightly if at all.

The halos present a fascinating and intricate problem in elementary optics—a problem which in spite of the contributions by Mariotte, Thomas Young, Venturi, Brandes, and Galle had been only very imperfectly worked out prior

to the masterly investigations of Bravais about 1845 and of which not all the details have yet been completely solved. Bravais [3] collected all known observations, discussed all the theories of each arc that had been proposed, and so far perfected and completed the theory in a consistent, systematic, and rigorous manner that his monograph immediately became the authority on the subject. His great classic has in the majority of its essential features stood almost intact to the present time and still is a standard source of information. In the case of each of 12 forms Bravais adopted some one of the explanations given by his predecessors, making them more complete and precise where necessary; and, by himself devising new theories for the others, he succeeded in giving what seemed to be satisfactory explanations of nearly all the authentically established forms then on record. He did not wholly escape errors, however, nor entirely clear up all difficulties, and additional observations are continually becoming available. J. M. Pernter was the first who subsequently sought to correct and extend Bravais' work on a comprehensive scale, and more recently important investigations have been made also by Besson, Fujiwhara, Hastings, Humphreys, Visser, Wegener, and others;[4] but many unsolved problems still remain.

The first step in developing a complete and systematic theory of halos is to trace by geometrical optics all the possible courses which may be followed by a ray of light incident upon, and either reflected from or refracted through, an ice crystal of given form. The position, on the sky, of the image due to light incident at a given point on a crystal in a given orientation may then be computed for any particular altitude of the sun or the moon; and, finally the locus of these images corresponding to any given set of different orientations of the crystal may be calculated. This locus represents the geometric form of the optical meteor which will be produced whenever crystals of the given form and with the corresponding orientations are present in the atmosphere but which will be distinguishable only if a sufficiently large proportion of the total light from the luminary be concentrated therein. For this part of the theory of halos, the sole physical principles required are the simple laws of refraction and reflection. The further discussion of observed halos involves the comparison and identification of the observed elements with the theoretical loci and an analysis of the relative frequency and brilliance of different arcs, the particular combinations of arcs that occur from time to time, the details of coloring, etc.

To accomplish the theoretical explanation of a particular observed halo it is necessary (1) to establish the fact of the existence of ice crystals of a certain form in the atmosphere, falling in a certain orientation, and (2) to identify the observed halo with one of the optical meteors which optical theory indicates would be produced by the given crystals in the given orientation. A common method of procedure is to ascertain, by reference to observational records, the forms which actually appear, and then to endeavor to explain them by seeking, in the case of each separately, some certain crystalline form and some particular orientation thereof which would produce that particular appearance. This method has serious limitations, among which is the fact that it is not legitimate to assume arbitrarily the existence, on any given occasion, of particular crystal forms in such numbers and special orientations as to be effective in just the way desired. In fact, the forms and orientations of the crystals responsible for a given halo display might better be deduced from the ensemble of arcs itself by the reverse procedure of comparing the observations with the results of a prior calculation of *all the possible* optical effects which *could* be produced under various conditions by each of the different forms of crystals which observation has shown to exist in the atmosphere from time to time and which are believed to take part in the production of halos.

In any case an essential part of the theoretical investigation of halo phenomena consists of the calculation of the luminous appearances which would be produced on the sky under favorable circumstances by crystals of given forms in given orientations. It would be an invaluable aid in the study of halo phenomena to have available a complete tabulation of all the optical effects that could be produced under various circumstances by each of all the forms of crystals known to be of importance. Such a systematic deduction of all the possible effects, as a method of attack in the theory of halos, was suggested some time ago by Hastings,[5] and has been partially carried out for some cases[6]; but no exhaustive application to all the crystal forms mentioned above has yet been published in detail. The object of the present study is to provide a complete investigation of this type, accompanied by an adequate set of formulas, tables, and diagrams, for the purpose of facilitating the discussion of observations and aiding to perfect the theory.

An immediate satisfactory solution of many of the still remaining problems is difficult or impossible by reason of the insufficient quantity and unreliable character of much of the available observational data and the lack of adequate and accurate measurements. The identification of each element of an observed halo complex with some one of the loci calculated in the geometrical theory is not always an easy problem; there are, e. g., three different theories of the infralateral tangent arcs to the 46° halo, and a set of apparently very careful measurements by Visser (*Kon. Akad. van Wet. te Amst.*, 26, Nos. 9–10, 1923) does not agree with any one of the three. Some of the rarer arcs have as yet been very inadequately observed and measured. Many observers report some of the well-known forms so erroneously that no great confidence can be felt in their descriptions of others, and consequently not all the forms on record can be considered genuine; but among those which apparently are authentic there remain a few whose explanations are unknown or in doubt. Further good observations [7] and additional theoretical investigation both are needed. A definitive solution of the unsolved problems must await the accumulation of more and better data, particularly in the case of the rare and doubtful forms. Meanwhile, a systematic computation by the formulas which the writer has developed should yield all theoretically possible forms; and among these should be found all the halos that ever are actually observed.

[3] A. Bravais. Mémoire sur les Halos et les Phénomènes optiques qui les accompagnent. Journal de l'Ecole Polytechnique, Trente-uniéme Cahier, T. xviii, pp. 1–270. Paris, 1847.

[4] The more important general treatises on the subject are W. J. Humphreys, *Physics of the Air*, 2 ed., New York, 1929; J. M. Pernter und F. M. Exner, *Meteorologische Optik*, 2te aufl., Wien und Leipzig, 1922; Alfred Wegener, Theorie der Haupthalos, *Arch d. Deutschen Seewarte*, Jahrg. 43, Nr. 2, Hamburg, 1926; Rudolf Meyer, *Die Haloerscheinungen*, Hamburg, 1929. There exists a large, but extremely scattered, journal literature. One of Bravais' principal errors, viz, the assumption that a crystal will fall in the orientation which offers the least resistance to the air, is of little importance in the purely geometrical problem with which we shall here be mainly concerned.

[5] Charles S. Hastings, A general theory of halos, MON. WEATHER REV., 48: 322–330, 1920.

[6] See, e. g., P. Putninš, Der Bogen von Parry und andere unechte Berührungsbogen des gewöhnlichen Ringes, *Met. Zeit.*, 51: 321–331, 1934.

[7] See Louis Besson, The different forms of halos and their observation, MON. WEATHER REV., 42: 436–446, 1914. An acquaintance with the general appearance of halo displays, and the ability to recognize the common arcs, are likely to contribute toward an accurate and adequate report. The observer should always state the latitude, longitude, and exact time of the observation; an accurate drawing should be made *during the observation* and should contain only what is *actually seen at one and the same time*. If instruments are available, the altitudes, azimuths, distances from the sun, etc., of conspicuous features should be carefully measured, and the altitude of the sun observed to provide a check for the investigator who uses the report; it should be plainly indicated, in any case where doubt can arise, whether angular readings refer to great circles or to horizontal angles. The coloring and any other notable features of the various elements should be fully described; and the clouds, state of the weather, general appearance of the sky, and description of the development and duration of the display should be given.

INTRODUCTION

A ray incident on one face of an ice crystal and emergent from another face will have undergone ordinary prismatic refraction, in which the angle between the two faces is the refracting angle. An application of the elementary law of refraction, $\sin i = \mu \sin r$, at both the point of incidence and the point of emergence leads to trigonometric relations (given in detail later in this paper) from which the position of the image *relative to that of the source* may easily be computed; the position, *relative to the horizon*, of the image formed by light incident on a particular face of an ice crystal of specified form in a given orientation is then readily found for any given altitude of the sun or moon by further trigonometric formulas. Similarly for images formed by reflection, or by a combination of both refraction and internal reflection. The locus of such of these images as correspond to any given set of different crystal orientations may then be obtained by appropriately varying in the formulas the parameters which specify the orientation of the crystal; the effects are always symmetrical about the solar or lunar meridian.

Undoubtedly there are always some crystals in each of all conceivable orientations in a cloud; but the locus of the images produced by the crystals in any particular set of these orientations will not be distinguishable unless sufficiently bright (both absolutely and relatively). Now, there are two factors, either of which will result in a relative concentration of the available light into the images produced by certain particular orientations: Crystals so oriented that the deviation by one of the refracting angles is a minimum will produce relatively bright images, because in the direction of minimum deviation there is a narrow and concentrated beam, while in other directions the light is diffuse and faint; the greatest intensity is at the minimum minimorum. Again, if there be a larger proportion of the crystals similarly oriented in some orientations than in others, the images produced by the former will be relatively the brighter. At oblique angles of incidence, much light is lost by external reflection, and the corresponding refraction halo will be faint. In general, a reflection must be a total internal one to result in a conspicuous effect.

Ordinarily, the only loci that actually become visible are produced by the simultaneous operation of *both* a predominant orientation and either a minimum deviation or a total reflection, but there are important exceptions. If conditions are such that the resistance of the air is able to dominate the orientation of the falling crystals to a sufficient degree, so that a large enough proportion of the crystals lie in the neighborhood of certain equilibrium positions, then the locus given by refraction at these equilibrium positions may appear even when the deviation is not a minimum; on the other hand, even when the crystals lie completely at random—equally distributed among all conceivable orientations—the concentration of light at minimum deviation may be sufficient for the appearance of the corresponding locus even though there are no more crystals in the necessary orientation than in any other orientation. Usually, however, it is only when a relatively large proportion of the crystals lie near particular orientations in which also the deviation is a minimum that the relative concentration of the available light into a particular locus is great enough to produce a distinct halo; and with few exceptions, when minimum deviation alone does give rise to a halo, it is the minimum minimorum which is necessary, while the production of a halo by a predominance of certain orientations alone requires the restricting influence to be effective enough to deprive a sufficient proportion of the crystals of *two* of their three degrees of rotational freedom.

It will be of interest to describe briefly a few illustrative examples of arcs produced in each of the above general ways:

When the crystals in a cloud lie completely at random—no more of them in any one orientation than in any other—each of the refracting angles will produce images in all directions from the source of light, and at all distances, beginning at the minimum minimorum, up to the maximum possible deviation; the result, when bright enough to be observed, is a circular halo around the luminary, at the distance corresponding to minimum minimorum. The 22° halo is produced in this way by the 60° refracting angles. The inner edge is sharp, and the sky within is comparatively dark; the outer edge is diffuse, the sky being illuminated with a white glare to some distance beyond the halo. Even when the crystals do not lie completely at random, there often are enough crystals in each of all orientations for this halo or a portion of it to appear; the 22° halo is exceedingly common, but it is seldom noticed by the casual observer, because usually it is quite faint, and often fragmentary and ephemeral. Similarly, the 46° halo is produced by 90° angles; and certain very rare halos of unusual radii by the angles in pyramidal crystals of various forms.[8] It is to the 22° ring that the term "halo" generically applies; but by extension it has come to be applied also to the other optical meteors of analogous origin.

Since the resistance of the air tends to restrict the freedom of motion of the crystals, they will not in general be distributed completely at random; but to a greater or less extent, depending on circumstances, a larger proportion of the crystals will lie in certain orientations than in others. In particular, hexagonal columns (with plane bases) tend to fall with the principal axis (i. e., the longer axis) horizontal, and are thus largely deprived of one degree of rotational freedom; to a lesser extent, they also tend either to keep one pair of lateral faces horizontal or else a diagonal of the hexagonal cross section vertical, and thus to be deprived of a second degree of freedom. We may therefore expect that in a cloud in which this type of crystal is present, a large proportion of the crystals will have their principal axes in or near a horizontal position, and, to a lesser extent, these will in turn tend to be in or near the equilibrium positions just mentioned: The crystals may rotate freely about a vertical axis, so that the principal axes will be distributed at random in azimuth; and they may also rotate about the principal axis, but will not be distributed completely at random in this respect.

As an example, consider any one of the 60° refracting angles in a crystal when the axis is constrained to remain horizontal. The refracting edge will be horizontal and the principal plane vertical. To compute the image produced, at any altitude of the sun or moon, when the refracting edge is in any azimuth and the faces of the angle at any inclination to the horizontal, the orientation of the face of incidence may conveniently be specified by the inclination of the normal to the horizontal, and the position of the axis by the azimuth θ of the normal, measured from the solar vertical; the position of the image is given by the trigonometric calculation of its azimuth and altitude, or its distance and position angle from the luminary.

To calculate the form of the optical meteors which will be produced when the crystals are deprived of only *one*

[8] See W. J. Humphreys, Physics of the Air, 2 ed., pp. 516-517; and MON. WEATH. REV. 50: 535-536, 1922; 51: 255-256, 1923; 61: 328-329, 1933.

degree of freedom, and hence rotate about both the principal axis and a vertical axis, we need consider only those angles so oriented as to give minimum deviation. The corresponding images are obtained by assigning a series of arbitrary values to θ, and giving the deviation its minimum value for each one, in the appropriate trigonometrical formulas; the resulting loci are known as the tangent arcs to the 22° halo, and are examples of arcs produced by the combined effects of minimum deviation (not minimum minimorum) and predominant orientation.

To calculate the halos which will be produced by crystals deprived of *two* degrees of freedom, and hence rotating only about a vertical axis, we need consider only the two equilibrium positions. The rare Parry arc above the 22° halo is due to light which is incident on the top faces of crystals which have two lateral faces horizontal; this arc is an example of a halo produced by a predominant orientation alone. A more common example is the circumzenithal arc, produced by 90° refracting angles with one face horizontal and the other vertical; in this case the general formulas show that the circumzenithal arc is simply a circle parallel to the horizon. It often occurs alone, and is the most brilliantly colored of all halos; in spite of its position in the sky it frequently is reported as a rainbow. The ordinary 22° sundogs are likewise due to crystals which have only one degree of freedom, but the principal plane of the refracting angle (60°) is horizontal in this case; it is to be noted that the sundogs are *outside* the corresponding halo—except when the luminary is on the horizon. The visible portion of the locus is ordinarily that at and near minimum deviation but is not at the minimum minimorum.

Reflection from vertical crystal faces rotating about a vertical axis produces the white parhelic circle, passing through the sun parallel to the horizon. Finally, an interesting example in which total internal reflection is involved may be mentioned: Light which at a high altitude of the sun falls upon the two upper sloping faces of hexagonal columnar crystals that have two lateral faces horizontal, and emerges from the lower horizontal face after internal reflection by a vertical plane base, the crystals being randomly oriented in azimuth, produces the so-called Lower Oblique Arcs of the Anthelion, which are among the rarely observed phenomena.[9]

The following sections [10] will present a systematic arrangement of formulas from which the various arcs mentioned above, as well as all others that can be produced in the different possible cases, may be computed.

[9] Edgar W. Woolard, On the Lower Oblique Arcs of the Anthelion, MON. WEATHER REV., 50: 537–539, 1922.
[10] To be published in later issues of the REVIEW.

WIND AND MINIMUM TEMPERATURE IN THE REDLANDS, CALIFORNIA, FRUIT-FROST DISTRICT

By JACK JANOFSKY

[Weather Bureau, Pomona, Calif., October 1936]

Fruit-frost work on the Pacific coast began in 1917. Starting with 2 widely separated stations, the service has since grown to include 18 winter and spring districts. The forecasting difficulties encountered in two different districts are never wholly alike, varying with the season and geographical location. When positive signs point to the development of ocean cloudiness, radiation fog, or wind during the night, no major forecasting difficulties are presented; but when indications are less definite, forecasting minimum temperatures becomes exceedingly difficult.

In the Redlands, Calif. district, wind is the important consideration; because no other phenomenon can there influence temperature forecasts so readily, it is especially deserving of critical treatment. The paper which follows presents a study of wind in the Redlands fruit-frost district, but the methods used should yield consistent results elsewhere.

The Redlands fruit-frost district lies in the northern extremity of the Great Valley of southern California, one of the richest citrus-growing centers in the world. Resembling a right triangle in shape, with the San Bernardino Mountain Range on the north as hypotenuse and the foothills of the San Jacinto Mountain Range on the south as base, the district is roughly 110 square miles in area. The foothill ranges converge in the east, with Crafton Hills, 3,540 feet high, closing the valley; but to the right and left rear are the San Gorgonia and San Jacinto peaks approximately 11,000 feet above sea level. The district opens in the west and merges 20 miles away with the flatter Great Valley to include the communities of Fontana and Bloomington as the western limits. The smooth valley floor slopes gently from the foothill areas and drains radially to the point of lowest elevation 7 miles southeast of Fontana, near Colton, about 950 feet above sea level. Elevation contours run in a general north-south direction in the east near Redlands, and an east-west direction near Fontana. A representative slope for the valley floor would be 75 feet per mile, but on approaching the foothills the slope gradient steepens rapidly.

Despite the small size of the district, forecasting minimum temperatures is complicated by a formidable wind problem. Winds, other than the usual canyon breezes, are generated and give relative immunity to frost at exposed places, whenever a strong area of high barometric pressure moves inland from off the northern California coast or develops over the plateau region. Fontana, which lies just southwest of a large mountain pass, is periodically subject to winds of this nature.

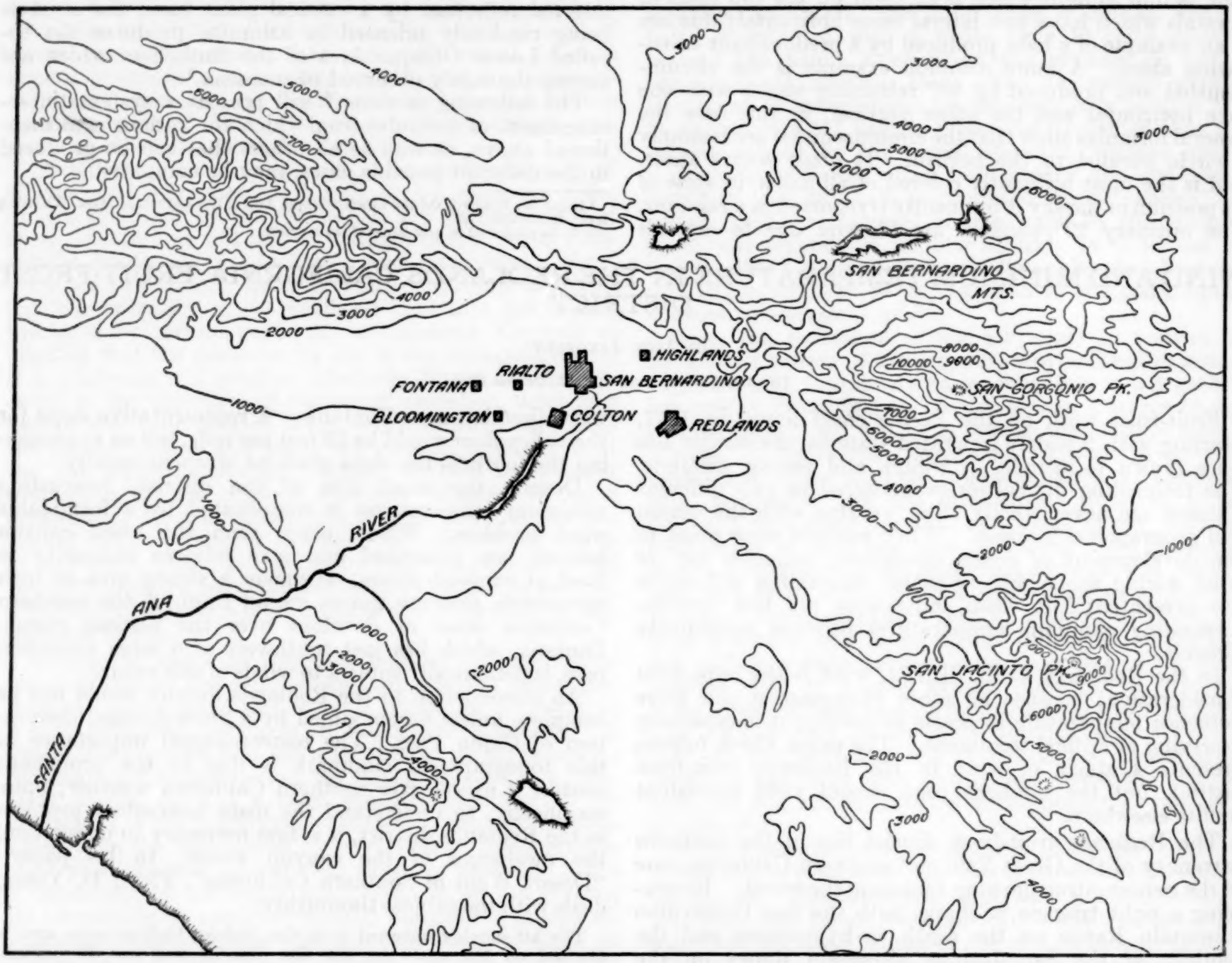
An introduction to the Redlands district would not be complete unless accompanied by a more detailed description of Cajon Pass. The meteorological importance of this topographical landmark is due to the prominent control it exerts over southern California weather; more specifically, to understand the main forecasting problem in the Redlands district, it is first necessary to understand the mechanics of the canyon winds. In his paper [1] "Desert Wind in Southern California", Floyd D. Young deals with the subject thoroughly:

> The air moving outward from the plateau high-pressure area is blocked on the south by the San Gabriel and San Bernardino Mountains. Wherever there is a break in these southern chains, such as Cajon Pass, the desert air streams through it and out onto the Great Valley of southern California. If the pressure difference between Nevada and southern California is only moderate, the desert winds usually are confined to rather narrow belts extending from the mouths of the passes to the ocean by the lowest and least obstructed route. * * *
>
> Cajon Pass lies between the San Gabriel and San Bernardino Mountain Ranges, extending roughly north and south, turning toward the southeast near its southern extremity. It is a V-shaped notch about 17 miles long and quite narrow, extending from the Mojave Desert on the north to the Great Valley of southern California on the south. The slope from the summit of the pass northeastward is gradual, the summit being only slightly higher than the general level of the desert. The fall from the summit toward the

[1] MONTHLY WEATHER REVIEW, 59: 380-381, October 1931.

south is more abrupt, averaging about 115 feet to the mile. The approach to the pass from the desert side is shaped like a great horizontal V, with the sides formed by the mountains, which converge at the entrance. * * *

Desert winds from Cajon Pass usually maintain their identity in a remarkable manner. They move out over the valley floor, swing toward the southwest, and either follow the canyon of the Santa Ana River through the Santa Ana Mountains or move directly over the low mountains south of the canyon and then follow a well-defined path over the almost level plains of Orange County, reaching the ocean in the vicinity of Newport. On going eastward in the open country some 7 miles south of Cajon Pass, with light to gentle variable winds, one passes abruptly into an air stream moving from the north-northeast at a velocity of 30 to 35 miles per hour. The easterly limits of the stream are just as well marked, and one passes from a near gale into a region of relative calm within the space of half a mile. The width of the air stream under these conditions



probably will average about 5 miles. * * * The stream may shift its position slightly from time to time but appears to change but little in width or velocity.

In the winter months the same factors generating desert wind in southern California bring frost to protected locations. It is only as the wind ceases that exposed stations experience freezing temperatures. This is particularly true for Fontana, where often after a windy period, and with minimum temperatures rising elsewhere, it will experience a separate "little freeze" of its own.

On the morning of December 17, 1935, the minimum temperature at the Redlands key station was 25°; but due to north wind the minimum temperature at the Fontana key station, only 12 miles away, was 54°. Starting December 14, firing to protect oranges at Redlands was necessary on six consecutive mornings; but for the same period the average minimum temperature at Fontana was 52.7°.

There were 46 cold nights during the 1935–36 frost season (cold night defined as one when some station in the district reports freezing temperature); and in 29 instances the minimum temperature at Fontana was as low or lower than at Redlands. In a few cases Fontana was as much as 5° colder than Redlands, but in all these cases north wind was conspicuously absent on the preceding afternoon. Either the evening charts showed light variable wind or calm at Fontana, or else the pressure distribution favored the cessation of north wind before morning. Classifying wind by direction, the following distribution was obtained: Wind with southerly component, 14; due west, 4; wind with northerly component, 6; due east, 2; and calm, 3. The case for Fontana being colder than Redlands in the absence of north wind at Fontana rests upon these figures.

The wide range for minimum temperatures within a relatively short distance is due mostly to wind mixing the upper air with the colder surface air. The higher the afternoon temperature the greater will be the tempera-

ture inversion during the night and the greater will be the effect of night winds. From the description of the conditions under which Fontana is as cold or colder than Redlands, it follows that whenever strong wind is blowing the temperature differences between the two stations will be dependent upon the degree of thermal stratification of air near the ground. For purposes of illustration three mornings have been selected when the minimum temperature at Redlands was 25° and wind centered at Fontana. The minimum temperatures at Fontana vary directly as the maximum temperatures observed at Redlands for the preceding afternoons (table 1).

On freeze nights with low (43°–47°) afternoon temperature, there is little temperature inversion, and wind will affect the temperature relatively little. Growers claim that during the 1913 freeze there was no temperature inversion and that temperatures as low as 15° were accompanied by winds strong enough to extinguish heaters.

TABLE 1.—*Minimum temperatures, °F., at Fontana, Calif., due to wind and temperature inversion*

Date	Minimum temperature		Preceding maximum temperature, Redlands
	Redlands	Fontana	
Dec. 17, 1935	24.7	53.8	70.4
Jan. 18, 1936	25.1	46.2	63.0
Feb. 10, 1933	25.2	34.8	55.4

In fruit-frost work no attempt is made to forecast numerical values for temperatures above 32°. Growers are concerned only when damaging temperatures are imminent, and 32° constitutes a "safe temperature" for citrus fruits. The foregoing temperature correlation table would appear to be of only nominal forecasting value because the prerequisite conditions for freezing temperature and wind develop only at infrequent intervals. A very important application to the estimation of temperatures within the wind belt is possible, however, when forecasting for marginal wind stations such as Colton.

Colton lies 5 miles southeast of Fontana. It presents by far the most perplexing problem in forecasting minimum temperature. There is neither a minimum temperature formula [2] available to assist in forecasting, nor a dependable desert wind flow; it is subject to intermittent breezes; the difference in minimum temperatures on consecutive mornings is often large and unexpected.

The minimum temperature at Colton usually lies somewhere between that at Redlands and that at Fontana, sometimes more nearly the latter and at other times close to the minimum at Redlands. In the absence of north wind, when Fontana is likely to be the coldest station in the district, the minimum temperature forecast for Colton is guided by the temperature expected at Fontana; but whenever north wind is blowing it is necessary to consider temperatures both within and outside the wind belt.

When pressure gradients are large, the wind at Fontana spreads out and covers the whole western sector of which Colton is a part, with resulting temperatures above freezing over the entire windy area. When the wind is just beginning or ending, or is restricted to its usual narrow path, Colton experiences intermittent wind, during lulls in which the temperature falls with astonishing rapidity. The final minimum will be somewhere between the lowest temperature in protected localities, such as Redlands, and the highest temperature within the center of the wind stream. Obviously it is much simpler to forecast minimum temperature for a station when the expected range is 25°–35° than when it is 25°–54°. If the wind at the marginal station is expected to produce only one-third the effect within the wind belt, a forecast of 28° will be issued for the first station, and an "above freezing" forecast (35°) for the second.

Paralleling somewhat the case of marginal wind is that of short-lived wind. Many times during a season wind will spring up locally in a district and die away just as suddenly, usually because of topographical differences between neighboring points or eddies from winds aloft. The duration and time of occurrence become very important considerations, for frost may precede or follow the wind.

If the wind is of short duration and occurs early in the evening, the temperature may still reach the value indicated by formula. The effect of short-lived winds is to break down surface temperature inversion and apparently [3] arrest nocturnal cooling; but the effective radiating temperature of the surface air layer is raised so that, when the wind ceases, cooling proceeds at a faster rate than prior to the wind. The final minimum temperature will depend on the soil temperature which ultimately should drop to its usual value, wind notwithstanding, due to the small penetration of the outer thermal changes into the lower soil.

However, if the conditions of wind alter late in the period, a complicated thermal condition results. The temperatures will be lower or higher than those prior to the wind action, and the occurrence or nonoccurrence of frost will be determined by the none-too-dependable breezes. Conservative practice is, after accurately gaging the minimum temperature at the coldest location, to issue equal or slightly higher forecast values of temperature for the wind-exposed places, according to the degree of wind expected.

The conditions which presage other than cyclonic winds in the Redlands district depend upon a strong area of high barometric pressure moving in, or developing over, the plateau region, or upon a deepening of low pressure over southern California. If both conditions occur simultaneously, then for a given pressure gradient between the two regions maximum wind results. Conversely, if the high pressure over the plateau disintegrates, or the pressure over southern California rises, the probability of wind decreases with the destruction of wind gradients.

In the discussion which follows, hard and fast rules for forecasting minimum temperatures as affected by wind have been deliberately avoided. It is evident that gentle breezes on nights with large temperature inversions may prevent the radiational fall to as great an extent as strong wind on nights with only small temperature inversion. The method used in forecasting minimum temperature for the Redlands district stresses, first, forecasting the occurrence of wind, and then the departures from lowest temperature in protected locations, according to the type of temperature inversion indicated by the maximum temperature.

The technique used in forecasting wind is based upon a study of critical values of pressure gradients between certain significant stations, and the attending 24-hour pressure changes. Under certain conditions either set of

[2] It should be understood that only for the main key station in a district is it practical to take psychrometric observations, and on them base an empirically determined, minimum temperature formula; for sectional key stations other than the main key station, modifications of the estimate by formula are necessary and depend upon known topographical differences and a rational analysis of the current weather map.

[3] "According to observations made by A. Ångström in California, with the ground 5° C. below air temperature the radiation emitted from the ground is reduced to about 93 percent of that of a black body at air temperature and the resultant outflow of radiation is reduced from 32 percent to 25 percent."—Meteorological Glossary, Second edition, p. 13.

data may singly indicate wind; but to cover all conditions favoring wind the two sets should be considered simultaneously.

By critical value of pressure gradient is meant the usual observed pressure difference between two significant stations when the wind is sufficiently strong in a sector to maintain temperatures above freezing. By observation it has been determined that whenever the pressure gradient between Tonopah and Los Angeles is 0.16 inch or more, Fontana will usually experience wind all night. When the Tonopah-Los Angeles pressure gradient is 0.20 inch, adjoining stations such as Bloomington and Rialto will usually share the wind with Fontana. In addition, when the Fresno-Los Angeles gradient is 0.16 or more, Colton, the marginal wind station, will also benefit from wind. But there still remain the nights like December 12, 1935 (see table 2), when the pressure gradient is less than the critical value, even negative, yet strong wind will blow somewhere in the district, thereby illustrating the fallacy of attempting to forecast wind by pressure gradients alone.

The 24-hour pressure change is used because station reports are received but once daily in the fruit-frost districts. It is conjectural whether the use of 12-hour pressure changes would be an improvement over this method, since the 24-hour changes are regarded as being more representative of the major changes in air mass that *lead to wind* in a district. Moderate changes in pressure over a 24-hour period reveal a definite tendency which may be logically projected into the next 16-hour forecast period; but the 12-hour pressure change may be less indicative.

In the 1935-36 season there were 18 nights with wind blowing somewhere in the Redlands district. Where the temperatures differ widely at the sectional key stations, the difference is due to wind. Table 2 lists chronologically these windy nights, giving the essential pressure data and temperatures. The type of wind, the path of wind, and the width of the belt may be inferred from an inspection of temperatures, except in the cases where additional information is provided in the notes. The sectional key stations are arranged in an east-to-west sequence, the band being approximately 12 miles long by 5 miles wide. The wind enters from a point on the northern border and usually is confined to a narrow path in crossing the strip.

Probably the most striking case during the season was following the night of January 16, when the wind reversed its usual habit and centered near Highland and Redlands, practically no wind being observed in the western sector. The conditions leading to this wind were the significant pressure gradient between Fresno and Los Angeles, and the large divergent pressure changes occurring simultaneously on the plateau and in southern California.

Other similar examples are the nights of December 8, 12, 18, and 31, and January 11. In nearly all these cases wind was experienced in Redlands shortly after midnight, but the main flow was centered in the western sector. Invariably with large Fresno-Los Angeles pressure gradient, and negative Tonopah-Los Angeles gradient, the wind as it issues from Cajon Pass will not experience its customary deflection toward the southwest and Fontana. It is only as the Tonopah-Los Angeles pressure gradient increases, and the Fresno-Los Angeles gradient decreases, that the wind can resume its normal path toward the sea, which predicates that the center of high pressure lies on the plateau rather than off the northern California coast.

TABLE 2.—*Wind data, 1935–36 frost season, Redlands, Calif.*

Date	24-hour pressure change (first line) and pressure gradients (second line)						Maximum temperature, Redlands, Calif.	Minimum temperatures for the following morning at sectional key stations						Notes
	Los Angeles	Tonopah	Fresno	Winnemucca[1]	Needles	Yuma		Redlands	Highland	Colton	Rialto	Bloomington	Fontana	
1935														
Nov. 14	+.14 -------	+.22 +.16	+.08 +.06	+.04 +.02	+.30 +.04	+.28 0	74	29	33	37	38	38	42	
Dec. 8	-.18 -------	-.02 +.14	-.12 +.16	+.04 +.12	-.18 -.02	-.20 -.06	65	39	Above freezing					Wind 2 a. m., 6 a. m. in Redlands.
Dec. 12	-.12 -------	-.08 -.06	+.10 +.12	+.12 +.08	-.32 -.16	-.22 -.12	62	35						Wind after 12:30 a. m. in all sectors.
Dec. 13	+.04 -------	+.38 +.28	+.12 +.20	+.36 +.06	+.28 +.08	+.20 +.04	70	28	29	34	47	53	52	
Dec. 14	+.08 -------	+.10 +.30	+.02 +.14	+.14 +.10	+.12 +.12	+.12 +.08	67	26	28	31	46	41	49	
Dec. 15	0 -------	-.02 +.28	0 +.14	-.08 +.08	-.06 +.06	-.06 +.02	68	26	26	27	38	33	52	
Dec. 16	+.04 -------	+.10 +.34	+.02 +.12	+.10 +.08	+.08 +.10	+.08 +.06	70	25	27	27	35	33	54	
Dec. 17	-.06 -------	-.18 +.22	-.14 +.04	-.14 +.12	-.04 +.12	-.06 +.06	70	26	27	30	43	41	54	
Dec. 18	-.04 -------	0 +.26	+.04 +.12	+.08 +.20	-.06 +.10	-.04 +.06	71	29	33	29	38	32	55	Wind in Highland and Rialto after 1 a. m. Redlands after 4 a. m.
Dec. 31	-.02 -------	+.20 +.14	+.14 +.18	+.30 +.04	-.02 -.04	-.04 -.02	65	34	Above freezing					Wind after 1 a. m. in Redlands.
1936														
Jan. 11	+.04 -------	-.02 -.14	+.18 +.08	+.22 +.06	-.14 -.20	-.04 -.12	63	34	34	34	33	36	49	
Jan. 16	-.12 -------	+.06 -.06	+.08 +.20	+.16 +.06	-.24 -.20	-.20 -.16	59	30	41	32	31	32	30	Wind in Highland all night. Wind in Redlands beginning 12:45 a. m. Average temperature thereafter, 40°.
Jan. 17	-.02 -------	+.26 +.22	-.02 +.20	+.26 +.06	+.18 0	+.12 -.02	63	25	30	40	46	48	46	
Jan. 19	-.12 -------	-.06 +.18	-.04 +.20	+.04 +.08	-.10 +.10	-.10 +.06	74	30	30	34	33	37	52	Wind path cut through Rialto town. Key station was 33°. Other survey stations only a few blocks away were above 40.°
Jan. 20	-.02 -------	+.02 +.22	-.04 +.18	+.02 +.08	-.04 +.08	-.04 +.04	75	33	32	38	45	38	55	
Jan. 21	+.10 -------	+.10 +.22	+.02 +.10	+.16 +.14	+.14 +.12	+.14 +.08	77	31	30	32	34	35	55	
Jan. 22	-.04 -------	-.08 +.18	-.02 +.12	-.08 +.14	-.06 +.10	-.06 +.06	76	34	32	35	32	38	58	
Jan. 29	+.06 -------	+.38 +.30	+.10 +.06	+.24 +.12	+.08 +.02	+.08 +.04	62	32	33	38	53	55	53	

[1] Represents pressure gradient from Winnemucca to Tonopah. The others are referable to Los Angeles.

The force of the wind and the relative values of contributing pressure gradients determine where the wind will strike. Pairs of gradients indirectly represent isobar curvature and orientation; and by grouping combinations of significant gradients in pairs, an empirical method which discounts topographical configurations as a further modifying influence is afforded, subject to the condition that as the barometric gradients become steeper, the ability of mountains or passes to deflect becomes decreasingly effective with the increased wind. With pressure gradients between the plateau and southern California in excess of 0.45 inch, the mountains to the north of the Great Valley lose their effectiveness as barriers, and desert air flows over their tops. (See table 3.)

TABLE 3.—*Wind path and significant pressure gradients*

Date	Pressure gradients		Maximum temperature	Ensuing minimum temperature					
	Los Angeles-Fresno	Los Angeles-Tonopah	Redlands	Redlands	Highland	Colton	Rialto	Bloomington	Fontana
			°	°	°	°	°	°	°
Jan. 16, 1936	+0.20	-0.06	59	[1] 30	41	32	31	31	30
Jan. 17, 1936	+.20	+.22	63	25	30	40	46	48	46
Dec. 17, 1935	+.04	+.22	70	26	27	30	43	46	54

[1] Wind after 1 a. m.; average temperature thereafter 40°. Bold-face figures show where wind centered.

Rates of pressure change at significant stations are important considerations. A difference in rate between two regions represents a resultant effect free to produce or maintain wind. If the pressure builds up or decreases everywhere alike, the flow remains unchanged; when the rates of pressure change are different, the gradients become accentuated. From the study of pressure data, it has been observed that any 24-hour pressure change at Tonopah greater than twice the magnitude of the 24-hour pressure change at Los Angeles is favorable for producing wind.

How the rates of pressure change may be the basis for wind forecasts is best demonstrated by reference to the nights of December 15, 16, and 17 in table 2. The evening of December 16 showed a moderate increase in the Tonopah-Los Angeles pressure gradient, but only a slight decrease in the Fresno-Los Angeles gradient. The 24-hour pressure change showed rates at Tonopah and Los Angeles in about a 2:1 ratio. In the table, opposite December 16 but for the morning of the 17th, Rialto minimum temperature has dropped to 35°; if the wind had continued to abate in that locality, freezing temperature should logically have been expected there and at Colton the following morning. On the evening of December 17, both the Tonopah-Los Angeles and Fresno-Los Angeles pressure gradients showed decided drops, but the wind increased at all locations, including Colton. The only apparent explanation is the difference in rates of pressure change. The 24-hour change at Tonopah over Los Angeles was in the ratio of 3:1.

It is understood, of course, that the principles enumerated herein only partly cover the problem. In some years pressure on the plateau runs consistently high merely because of the hypothetical reduction to sea level; at other times the vertical structure of the air over the Great Valley determines whether the wind will blow along the surface or merely through the tops of the tallest windbreak trees. In the first case, a given pressure gradient between the plateau and southern California produces a minimum amount of wind; and, in the second case, additional considerations preclude exact analysis of impending minimum temperature. Wind seldom, if ever, completely conforms with expectation. This paper can only represent an attempt to circumvent certain frost-forecasting difficulties encountered in the field.

TROPICAL DISTURBANCE, OCTOBER 9–10, 1936

By I. R. TANNEHILL

[Marine Division, Weather Bureau, Washington, November 1936]

Only one tropical disturbance was reported during October from the North Atlantic Ocean (including the Gulf of Mexico and Caribbean Sea); this disturbance was of slight intensity; it was in evidence on October 9 and 10 on the west coast of Yucatan and in the Bay of Campeche.

The initial stages of the disturbance are described in the report of W. R. Stevens, forecaster on duty at New Orleans, as follows:

For a few days previous to October 9, conditions had been unsettled over the northwest Caribbean Sea, attended by slowly falling pressure over the Yucatan Peninsula. Heavy rains were reported on the morning of October 9 at Payo Obispo and Cozumel Island. The 8 p. m. map of October 9 showed a definite circulation over the Gulf of Campeche and the pressure at Merida had fallen to 29.70 inches, representing a 24-hour pressure fall of 0.08 inch, while pressure had risen slightly on the east coast of the Yucatan Peninsula. The reports at hand indicated that the disturbance was just forming and was probably central near Campeche.

Observations from the vicinity of the disturbance are inadequate to determine the exact course of the center; it appears to have moved south-southwestward across the Bay of Campeche and inland a short distance east of Frontera on October 10. The situation on the morning of the 11th, when the disturbance was centered north of Tapachula, is shown on chart IX.

Advisory information regarding the disturbance was disseminated on the 9th and 10th from the New Orleans forecast center.

An account of tropical disturbances which occurred during October in the Pacific Ocean near Mexico will be found on page 343.

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By AMY D. PUTNAM

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING OCTOBER 1936

By IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January 1935 REVIEW, page 24.

Table 1 shows that solar radiation intensities averaged close to normal at all three Weather Bureau stations.

TABLE 1.—*Solar radiation intensities during October 1936*

[Gram-calories per minute per square centimeter of normal surface]

Date	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
		Sun's zenith distance									
	75th mer. time	Air mass A. M.					Air mass P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
WASHINGTON, D. C.											
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Oct. 2	8.48	0.70	0.79	0.92	1.14	1.35	1.06	0.92	0.81	0.69	7.29
Oct. 12	6.27			1.09	1.24	1.39					6.50
Oct. 13	5.16			.81	1.01	1.39					5.79
Oct. 19	6.76	.67	.76	.90	1.16	1.42					7.04
Oct. 20	8.81	.81	.89	1.06	1.22	1.44	1.22	1.04	.94	.83	6.53
Oct. 21	10.59	.81	.92	1.07	1.26	1.39	1.28	1.11	.99	.89	11.81
Oct. 27	2.87	.89	.96	1.10	1.35	1.49					2.16
Oct. 29	5.36			.70	0.86						4.37
Oct. 30	3.99	.60	.75	.93							3.63
Means		.74	.84	.95	1.16	1.41	1.19	1.02	.91	.80	
Departures		−.01	−.01	−.02	+.03	−.01	+.06	+.07	+.09	+.06	
MADISON, WIS.											
Oct. 2	3.81		0.86	1.14	1.21	1.40					4.95
Oct. 8	7.87	0.95	1.09		1.40						7.57
Oct. 15	8.81						1.08				11.81
Oct. 19	7.57				1.22						10.21
Oct. 27	2.62				1.32						3.00
Oct. 29	4.17				1.30						3.63
Means		(.95)	(.98)	(1.14)	1.29	(1.40)	(1.08)				
Departures		+.15	+.06	+.09	+.09	−.03	−.12				
LINCOLN, NEBR.											
Oct. 1	4.95	0.89	1.05	1.19	1.31	1.51					4.75
Oct. 5	10.97		.68	.83	1.08	1.43					11.81
Oct. 7	5.56			1.05	1.26	1.59	1.26	1.06	0.93	0.84	5.56
Oct. 15	10.59		.73	.82	1.07	1.59					10.97
Oct. 20	8.81				1.24						5.56
Oct. 22	2.49	1.00	1.11	1.25	1.43		1.39	1.24	1.08	.96	2.36
Oct. 23	2.74				1.32		1.25	1.06	.95	.82	2.49
Oct. 24	3.45	.90	.99	1.15	1.35						4.57
Oct. 26	2.16						1.40	1.24	.98	.71	2.06
Oct. 29	3.63						1.36	1.20	1.06	.90	3.81
Oct. 30	3.30		1.09	1.22							7.57
Oct. 31	10.21	.86	.91	1.00							9.83
Means		.91	.94	1.06	1.26	1.53	1.33	1.16	1.00	.85	
Departures		+.08	+.01	−.03	−.03	+.05	+.08	+.08	+.06	+.02	

TABLE 1.—*Solar radiation intensities during October 1936*—Contd.

[Gram-calories per minute per square centimeter of normal surface]

BLUE HILL, MASS.

Date	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
		Sun's zenith distance									
	75th mer. time	Air mass A. M.					Air mass P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Oct. 2	7.9			0.95	1.04	1.25	1.16				7.9
Oct. 3	5.8	1.01	1.04	1.18	1.30	1.44	1.30	1.12			4.8
Oct. 4	5.6		.97	1.08	1.22	1.38	1.21	1.02	0.80		6.5
Oct. 5	8.2		.88	1.14	1.14						7.9
Oct. 6	9.2		.88	1.22			1.22	1.01	.84		9.2
Oct. 8	13.2		.78	.93			1.20	.94	.73		9.9
Oct. 9	6.8		.70		1.05						6.1
Oct. 12	6.1				1.18		1.35	1.24	1.14	1.06	5.2
Oct. 13	3.5		1.04	1.14	1.24						2.9
Oct. 18	7.4		.82	.94	1.35						5.2
Oct. 19	5.2	.85	.94	1.04							5.2
Oct. 20	8.2		.60	.73	.94		.98	.78	.71	.65	6.8
Oct. 21	19.6		1.09	1.20	1.31						8.2
Oct. 22	12.8				1.07						12.3
Oct. 24	6.8	.68							.89		7.4
Oct. 25	3.8			1.08	1.19						5.4
Oct. 27	2.1			1.26	1.36		1.36	1.26	1.16	1.06	1.8
Oct. 28	2.9			1.26	1.37		1.37	1.26	1.15	1.05	2.4
Oct. 29	5.8			1.07	1.10		1.10	.63			3.8
Oct. 30	5.0				1.07		1.16				2.8
Oct. 31	2.8	1.02	1.11	1.23	1.35						2.8
Means		.89	.90	1.09	1.19	1.36	1.22	1.03	.94	.96	

[1] Extrapolated.

Table 2 shows a deficiency in the amount of total solar and sky radiation received on a horizontal surface at all stations with the exception of Washington, Lincoln, Madison, Fairbanks, and New Orleans.

The Callendar receiver and recording Wheatstone bridge which have been in constant service for the last 25 years at Madison, Wis., for measuring total solar and sky radiation received on a horizontal surface, were replaced early in the month by an Eppley 10-junction thermoelectric pyrheliometer and a Leeds and Northrup recording micromax potentiometer. At the same time the Marvin pyrheliometer in use at that station for measuring normal incidence radiation was checked against Smithsonian silver-disk pyrheliometer no. 1, which instrument had been checked against Smithsonian standards at the Smithsonian Astrophysical Observatory a few weeks before.

Polarization observations made at Washington on 3 days give a mean of 57 percent with a maximum of 61 percent on the 27th. At Madison, observations made on 3 days give a mean of 60 percent with a maximum of 70 percent on the 29th. All of these values are slightly below the corresponding normals for the month.

TABLE 2.—*Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface*

Week beginning—	Gram-calories per square centimeter															
	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca
1936	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Oct. 1	351	273	353	232	289	428	156	350	379	401	332	374	336	425	243	302
Oct. 8	250	173	316	204	181	426	71	318	333	322	381	410	254	460	242	232
Oct. 15	295	239	296	243	242	282	76	235	257	411	364	233	239	513	265	192
Oct. 22	274	276	335	151	205	371	27	262	318	386	296	366	223	477	158	205
	Departures from weekly normals															
Oct. 1	+15	−3	+16	−30	+6	−6	+47	−35	--------	−5	−18	−13	+2	--------	+17	+27
Oct. 8	−57	−69	+10	−24	−85	+21	−1	−45	--------	−46	+41	+47	−67	--------	+6	−57
Oct. 15	+12	+22	−4	+32	+28	−89	+13	−109	--------	+56	+46	−117	−57	--------	+70	−78
Oct. 22	+7	+71	+57	−28	+11	+3	−26	−35	--------	−12	+6	+24	−41	--------	−6	0
	Accumulated departures on—															
	+5,754	+2,569	+7,595	+10,416	+6,741	+4,592	+4,382	−2,674	--------	−7,868	--------	−434	−1,575	--------	+1,162	+987

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during October 1936 and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated.*

AMERICAN UNIVERSITY, WASHINGTON, D. C.

Date and hour angle	Solar altitude		Air mass	I_m	I_y	I_r	$\beta_{I_{yr}}$	$\frac{I_{w=o}}{1.94}$	$\frac{I_{w=o}-I_m}{1.94}$	w	Air-mass type
								Percentage of solar constant			
1936											
Oct. 2	°	′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*				*mm*	
1:24 a. m.	43	15	1.46	1.182	0.838	0.658	0.061	77.5	15.9	40.0	N_{PC}; S Aloft.
1:20 a. m.	43	37	1.45	1.186	.838	.658	.062	77.6	15.8	40.0	
Oct. 12											
0:28 a. m.	43	09	1.46	1.283	.912	.730	.065	76.8	11.0	15.5	N_{PC}.
0:12 a. m.	43	31	1.45	1.304	.915	.732	.066	77.0	10.1	10.1	
Oct. 21											
2:28 a. m.	29	31	2.02	1.262	.923	.730	.023	80.3	15.7	38.0	$N_P \rightarrow T_M$; S Aloft.
2:20 a. m.	30	34	1.96	1.283	.926	.733	.025	79.6	14.0	33.0	

Atmospheric conditions during turbidity measurements

Oct. 2. Temperature 22° C.; wind, NE 8; visibility, 12 miles.
Oct. 12. Temperature 21° C.; wind, NW 12; visibility, 30 miles.
Oct. 21. Temperature 23° C.; wind, S 8; visibility, 20 miles. Polarization, 53 percent.

BLUE HILL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle	Solar altitude		Air mass	I_m	I_y	I_r	$\frac{I_y}{0.851\text{-}c}$	$\frac{I_r}{0.840\text{-}c}$	β	$\frac{I_{w=o}}{1.94}$	$\frac{I_{w=o}-I_m}{1.94}$	w
1936												
Oct. 2	°	′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*
3:52 a. m.	20	24	2.85	0.965	0.683	0.575	0.801	0.683	0.110	54.2	5.6	4.0
1:10 a. m.	41	26	1.51	1.085	.740	.600	.868	.713	.141	67.4	11.4	9.3
Oct. 3												
3:57 a. m.	18	48	3.10	1.171	.819	.677	.960	.804	.167	63.8	3.4	1.2
2:45 a. m.	30	05	1.99	1.303	.877	.716	1.028	.850	.071	70.6	3.4	1.2
0:39 a. m.	42	38	1.48	1.411	.918	.762	1.077	.905	.078	75.4	2.7	2.2
0:07 p. m.	43	37	1.45	1.362	.918	.724	1.074	.918	.075	76.8	6.1	5.1
2:16 p. m.	34	23	1.77	1.319	.884	.723	1.021	.850	.081	72.0	4.0	3.0
Oct. 4												
3:19 a. m.	25	08	2.35	1.191	.822	.625	.966	.803	.071	67.7	6.3	4.5
2:37 a. m.	30	54	1.94	1.220	.820	.673						
2:47 p. m.	39	48	1.95	1.259	.780	.634	.915	.753	.074	69.5	5.6	4.6
3:34 p. m.	23	22	2.56	1.083	.743	.610	.872	.727	.057	68.2	12.4	7.8
Oct. 5												
3:52 a. m.	19	31	2.98	.887	.624	.531	.732	.631	.119	52.4	6.7	3.9
2:34 a. m.	31	08	1.93	1.163	.741	.608	.869	.721	.098	65.8	6.9	5.0
Oct. 6												
4:04 a. m.	18	42	3.10	1.142	.804	.667	.943	.792	.063	61.8	2.9	1.7
Oct. 8												
4:27 a. m.	22	44	2.64	.804	.599	.511	.702	.606	.121	64.2	3.7	1.9
1:04 p. m.	39	38	1.57	1.175	.818	.680	.959	.808	.150	63.3	2.8	2.3
3:03 p. m.	26	14	2.26	1.116	.782	.633	.918	.752	.071	68.7	9.9	6.6
4:09 p. m.	15	54	3.61	.809	.619	.506	.725	.601	.085	52.8	11.2	5.9
Oct. 9												
3:10 a. m.	24	59	2.45	.790	.578	.509	.699	.602	.175	47.7	7.1	4.6
0:57 p. m.	46	00	1.55	1.164	.810	.670	.949	.795	.151	65.7	5.8	3.2

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during October 1936 and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated*—Continued

BLUE HILL OBSERVATORY OF HARVARD UNIVERSITY—Continued

Date and hour angle	Solar altitude		Air mass	I_m	I_y	I_r	$\frac{I_y}{0.851-c}$	$\frac{I_r}{0.840-c}$	β	$\frac{I_{w-c}}{1.94}$	$\frac{I_{w-c}-I_m}{1.94}$	w
1936												
Oct. 12	°	′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*
2:37 a. m.	28	53	2.06	1.184	0.802	0.671	0.936	0.798	0.118	63.8	2.9	2.0
1:21 a. m.	36	15	1.69	1.216	.800	.647	.938	.783	.100	68.5	6.7	5.2
2:23 p. m.	30	32	1.96	1.360	.906	.727	1.060	.862	.044	75.0	5.6	4.0
4:24 p. m.	12	10	4.64	1.082	.749	.632	.877	.751				
Oct. 13												
4:06 a. m.	14	55	3.84	1.058	.760	.637	.888	.753	.055	58.7	4.4	2.3
1:52 a. m.	33	43	1.80	1.264	.820	.660	.958	.781	.089	68.8	3.9	3.0
Oct. 18												
3:34 a. m.	18	47	3.08	1.100	.759	.632	.890	.757	.073	59.7	3.0	1.7
Oct. 19												
3:00 a. m.	23	44	2.48	1.186	.811	.666	.951	.791	.070	65.2	5.1	3.3
Oct. 20												
2:59 a. m.	23	18	2.52	.806	.568	.488	.664	.577	.179	60.6	9.2	5.9
0:20 p. m.	37	08	1.65	1.082	.715	.593	.833	.700	.148	61.0	5.4	3.9
3:36 p. m.	18	04	3.19	.750	.541	.444	.633	.526	.167	51.5	13.0	7.6
Oct. 21												
2:42 a. m.	25	14	2.34	1.275	.831	.678	.973	.804	.076	76.9	11.2	7.4
Oct. 22												
2:53 a. m.	23	40	2.48	.995	.686	.557	.802	.661	.094	60.6	8.5	5.4
Oct. 24												
4:02 p. m.	12	24	4.57	.839	.611	.508	.712	.600	.062	54.0	11.0	5.3
Oct. 25												
3:08 a. m.	20	34	2.82	1.092	.762	.624	.887	.735	.064	62.1	6.8	4.1
0:24 a. m.	35	30	1.72	1.092	.745	.601	.867	.708	.063	64.0	8.5	6.5
Oct. 27												
3:08 a. m.	20	04	2.89	1.273	.863	.711	1.002	.836	.050	74.2	8.9	5.3
0:17 a. m.	34	33	1.76	1.358	.908	.735	1.104	.867	.004	74.2	4.6	3.5
3:49 p. m.	22	45	2.58	1.308	.890	.712	1.036	.838	.024	76.0	7.4	4.7
Oct. 28												
3:08 a. m.	19	43	2.95	1.269	.869	.699	1.011	.822	.025	81.3	10.6	6.2
0:18 a. m.	34	25	1.77	1.378	.906	.730	1.051	.859	.017	73.7	3.0	2.3
2:58 p. m.	21	04	2.76	1.119	.772	.625	899	.737	.057	65.6	8.3	5.1
Oct. 29												
2:09 a. m′.	27	05	2.19	1.070	.723	.587	.841	.691	.082	64.8	10.0	6.8
0:13 p. m.	42	09	1.80	1.081	.727	.590	.846	.696	.150	64.3	8.9	6.7
2:55 p. m.	21	21	2.74	.672	.479	.405	.578	.477	.140	46.3	11.9	7.3
Oct. 30												
2:09 a. m.	26	33	2.24	1.112	.740	.600	.859	.707	.094	63.0	6.1	4.1
2:58 p. m.	20	35	2.82	1.164	.782	.660	.910	.778	.087	59.5	6.1	3.7
Oct. 31												
3:54 a. m.	12	08	4.68	1.044	.747	.620	.868	.729	.033			
2:50 a. m.	21	22	2.72	1.261	.845	.677	.981	.797	.038	71.0	11.6	7.1
0:13 p. m.	33	29	1.81	1.358	.881	.698	1.026	.824	.046	75.9	10.3	7.7

Air-mass types for above table

Oct. 2. N_{PC}	Oct. 9. N_P	Oct. 20. $N_{PC}+S$	Oct. 27. P_C
3. N_{PC}	12. N_P	21. T_M+S	28. N_{PC}
4. P_C	13. P_C	22. T_M	29. N_P
5. N_{PC}	18. P_C	24. N_{PC}; T_M aloft	30. P_C+P_P
6. $N_{PC} \rightarrow T_M$	19. N_{PC}	25. N_{PC}	31. N_P
8. N_P			

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during September 1936, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated, Blue Hill, Mass.*

Date and hour angle	Solar altitude		Air mass	I_m	I_y	I_r	$\beta_{I_{y-r}}$	$\frac{I_{w-c}}{1.94}$ (Percentage of solar constant)	$\frac{I_{w-c}-I_m}{1.94}$ (Percentage of solar constant)	w	Air-mass type
1936, Sept. 1	°	′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*				*mm*	
4:38 a. m.	20	41	2.77	1.067	0.757	0.629	0.075	61.9	5.9	3.6	N_{PC}
3:19 a. m.	34	48	1.75	1.214	.826	.675	.091	69.9	6.2	4.7	
2:52 a. m.	39	39	1.57	1.247	.848	.685	.083	72.3	6.9	5.5	
5:30 p. m.	11	56	4.95	.673	.504	.435					
Sept. 3											
4:26 a. m.	22	45	2.58	.892	.640	.528	.112	56.1	9.3	5.8	$N_P \longrightarrow T_M$
Sept. 4											
0:40 p. m.	54	01	1.24	1.269	.837	.684	.109	73.6	7.1	6.5	N_{PC}
2:58 p. m.	37	43	1.63	1.179	.786	.645	.130	64.9	3.1	2.4	
3:15 p. m.	34	51	1.78	1.159	.776	.641	.125	65.7	5.0	3.8	
Sept. 6											
4:40 a. m.	19	15	3.02	1.017	.718	.599	.079	59.2	5.9	2.8	N_{PC}
4:14 a. m.	23	58	2.46	1.101	.755	.621	.077	64.0	6.7	4.1	
3:33 a. m.	36	33	1.91	1.179	.787	.647	.087	67.0	5.5	4.0	
0:00 noon	54	23	1.23	1.261	.822	.664	.149	69.0	2.9	2.6	

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during September 1936, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated, Blue Hill, Mass.*—Continued

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	$\beta_{I_{y-r}}$	$\frac{I_{w=0}}{1.94}$ (Percentage of solar constant)	$\frac{I_{w=0}-I_w}{1.94}$ (Percentage of solar constant)	w	Air-mass type
Sept. 7	° ′	m	*gr. cal.*	*gr. cal.*	*gr. cal.*				*mm*	
4:33 p. m.	20 14	2.88	0.586	0.432	0.374					T_M
Sept. 8										
1:30 a. m.	48 34	1.33	1.045	.709	.578	.164	65.5	10.9	9.6	T_M
0:44 a. m.	52 34	1.26	1.069	.715	.582	.175	63.2	7.6	6.8	
Sept. 9										
4:13 a. m.	23 30	2.50	.741	.550	.471	.203				$N_P \longrightarrow T_M$
3:01 a. m.	35 41	1.74	.997	.669	.563	.202	60.8	8.5	5.0	
2:33 a. m.	47 50	1.34	1.043	.701	.576	.205	59.8	5.5	4.8	
0:05 p. m.	53 16	1.25	1.217	.795	.635	.150	68.5	5.1	4.6	
0:28 p. m.	52 45	1.26	1.236	.816	.653	.100	74.6	10.2	9.2	
Sept. 11										
2:52 p. m.	36 31	1.68	1.137	.761	.644	.184	64.2	4.8	3.8	N_{PC}
3:02 p. m.	35 00	1.74	1.123	.741	.622	.175	64.2	5.5	4.2	
3:36 p. m.	29 16	2.04	1.071	.741	.612	.133	61.7	5.8	4.1	
Sept. 14										
4:23 a. m.	20 11	2.86	1.110	.772	.642	.075	61.0	3.2	1.9	N_{PA}
4:05 a. m.	23 32	2.50	1.150	.792	.646	.066	63.9	4.0	2.5	
Sept. 16										
1:26 p. m.	45 59	1.39	1.635	.695	.555	.162	63.0	9.1	7.8	N_{PA}:T_M Aloft.
4:01 p. m.	23 34	2.49	.735	.544	.462					
Sept. 17										
4:38 a. m.	16 05	3.57	.445	.351	.323					N_{PA}:T_M Aloft.
4:13 a. m.	21 00	2.77	.682	.379	.360					
Sept. 19										
0:51 p. m.	47 49	1.35	1.372	.891	.711	.070	77.5	6.0	5.2	N_{PA}:T_M Aloft.
4:29 p. m.	17 48	3.24	1.049	.739	.602	.050	63.9	9.4	5.3	
5:19 p. m.	9 24	5.95	.790	.589	.494					
5:35 p. m.			.673	.511	.454					
Sept. 22										
2:43 p. m.	34 36	1.76	1.017	.672	.547	.156	58.8	5.5	3.3	N_{PC}.
3:16 p. m.	29 27	2.03	.899	.604	.509	.201	49.6	3.0	2.1	
Sept. 23										
0:13 p. m.	47 46	1.34	1.060	.699	.576					$N_P \rightarrow T_M$:S Aloft.
0:39 p. m.	46 57	1.37	1.124	.721	.592	.195	61.5	1.1	1.0	
1:31 p. m.	43 09	1.46	1.169	.761	.617	.158	64.4	4.3	3.6	
3:50 p. m.	23 31	2.50	1.001	.667	.547	.105	58.2	6.2	4.0	
Sept. 24										
1:00 a. m.	41 54	1.49	1.259	.811	.656	.114	69.0	3.8	3.1	$M_P \rightarrow T_M$: S Aloft.
0:10 a. m.	47 15	1.36	1.285	.832	.667	.106	70.3	4.3	3.7	
0:51 p. m.	45 57	1.39	1.308	.845	.775					
Sept. 25										
4:30 a. m.	16 15	3.55	1.159	.816	.671	.032	68.3	8.4	4.5	P_C: S Aloft.
4:10 a. m.	19 47	2.93	1.240	.848	.703	.051	69.3	5.2	3.1	
1:58 a. m.	40 34	1.53	1.435	.941	.762	.051	77.0	2.8	2.3	
0:21 p. m.	46 52	1.37	1.466	.941	.762	.076	79.0	3.2	2.8	
2:16 p. m.	37 19	1.65	1.388	.906	.743	.075	74.0	2.2	1.7	
Sept. 26										
4:32 a. m.	15 25	3.72	.980	.706	.588	.074	54.5	3.8	2.1	P_C
4:15 a. m.	17 58	3.06	1.098	.776	.627	.050	66.0	8.0	4.6	
0:00 noon	46 42	1.38	1.216	.809	.661	.140	67.4	4.3	3.7	
0:23 p. m.	46 24	1.38	1.243	.817	.673	.148	66.5	2.4	2.1	
3:12 p. m.	28 52	2.06	1.285	.855	.693	.050	73.2	6.8	4.8	
3:31 p. m.	25 44	2.30	1.205	.834	.679	.050	81.2	19.1	12.7	
Sept. 28										
0:13 p. m.	42 23	1.48	1.364	.878	.708	.059	79.0	8.4	7.0	N_{PC}.
Sept. 29										
3:51 a. m.	21 38	2.70	1.200	.816	.674	.037	69.7	7.6	4.7	
2:00 a. m.	37 02	1.66	1.340	.888	.725	.075	73.7	4.4	3.4	P_C: S Aloft.

Atmospheric conditions during solar radiation measurements, Blue Hill Observatory of Harvard University, October 1936

Date	Time from apparent noon	Air temperature ° C.	Wind, Beaufort	Visibility 0–10	Sky blueness	Cloudiness and remarks
Oct. 2	3:52 a. m.	10.5	NNW 3	8	7	1 Ci; moderate haze.
3	2:44 a. m.	10.5	NW 3	8	7	Zero clouds; light haze.
3	0:03 a. m.	12.8	NNW 3	9	8	Few Ci; few Cu; light haze.
4	2:55 a. m.	9.3	NE 3	6	8	Few Acu; dense haze.
4	0:09 p. m.	13.9	NE 2	8	8	1 Cu; light haze; Cu, near sun.
4	3:14 p. m.	14.5	SE 2	8	8	2 Cu; light haze; FrCu, near sun.
5	3:49 a. m.	11.8	SW 3	7	8	Few Acu; moderate haze.
6	3:54 a. m.	12.8	SSE 3	8	8	1 Ci; 1 Acu; moderate haze.
8	3:04 a. m.	16.7	WNW 3	7	7	3 Ci; moderate water haze.
10	3:02 a. m.	11.7	N 3	7	8	Few Ci; moderate haze.
11	2:56 a. m.	11.6	WSW 5G	8	9	Few Ci; few Cu; light haze.
11	1:52 p. m.	9.8	W 6G	9	8	Few Cu; FrCu; very light haze.
13	2:14 a. m.	5.4	NW 2	9	8	Few Acu; very light haze.
18	3:23 a. m.	10.6	SW 5	8	8	1 Cu.
20	2:56 a. m.	13.8	SW 5	7	8	Zero clouds; moderate haze.
20	0:00 a. m.	19.7	WSW 5	8	8	Do.
25	3:03 a. m.	6.9	NE 2	7	8	Few Cu; moderate haze.
27	3:03 a. m.	−4.4	NW 3	9	8	Few Cu.
27	0:14 a. m.	−1.0	NW 2	9	8	Zero clouds; light haze.
28	0:15 a. m.	5.8	W 3	8	8	Zero clouds; moderate haze in north.
29	2:06 a. m.	6.8	SW 2	7	8	Few Acu; moderate haze.
29	1:16 p. m.	10.9	SW 3	7	8	Zero clouds; moderate haze.
31	3:08 a. m.	.7	WNW 5G	9	8	Few Cu; light haze north; instrument indoors.
31	0:17 a. m.	5.3	NW 4	9	8	2 Ci; light haze north and east.

Atmospheric conditions during solar radiation measurements, September 1936

Date	Time from apparent noon	Air temperature ° C.	Wind, Beaufort	Visibility 0–10	Sky blueness	Cloudiness and remarks
Sept. 1	3:16 a. m.	15.3	WSW 4	9	8	Few Cu; light haze.
4	2:58 p. m.	17.4	NE 2	8	8	2 Acu; 2 Cu; light haze.
6	4:38 a. m.	14.3	SSW 3	9	9	Few Ci; very light haze.
8	1:05 a. m.	27.2	W 3	7	7	3 Acu; moderate haze.
9	2:58 a. m.	22.4	NW 1	6	6	1 Acu; dense haze.
9	0:07 p. m.	26.1	W 2	8	8	Few Cu; 1 Cu; light haze.
11	3:05 p. m.	21.8	SSE 2	7	8	3 Ci; dense haze.
14	4:23 a. m.	11.8	NE 4	9	8	Few Ci; few Cu; moderate haze.
16	1:33 p. m.	22.6	SSW 5	8	7	1 Cu; light haze.
19	5:14 p. m.	18.9	NW 3	9	8	Few Cu.
22	2:56 p. m.	24.5	SSW 3	8	8	2 Ci; 1 Cu; light haze.
23	0:14 p. m.	23.2	S 3	6	6	Zero clouds; dense haze.
24	0:52 a. m.	22.0	E 2	7	7	2 Ci; few Cu; dense haze.
25	4:29 a. m.	7.9	WNW 5	9	9	Few Stcu.
25	0:22 p. m.	11.9	NW 5	8	8	Few Ci; few Cu.
26	4:33 a. m.	5.3	NE 2	9	9	2 Acu; light haze.
26	0:02 p. m.	13.2	S 1	9	8	Few Acu; light haze.
26	3:12 p. m.	13.2	E 3	9	8	2 Ci; light haze.
29	3:51 a. m.	6.7	NNW 4	9	8	Few Acu; few Cu; light haze.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1936	h. m.	°	°	°				
Oct. 1	11 16	−62.0	294.0	+19.5		340		U. S. Naval.
		−29.0	327.0	+18.0		401		
		−28.5	327.5	−19.0		62		
		−26.0	330.0	+7.5		46		
		+43.0	39.0	−19.0	15			
		+47.0	43.0	+17.5		62		
		+63.0	59.0	−24.5		123	1,049	
Oct. 2	10 56	−63.0	280.0	−19.0		77		Do.
		−49.0	294.0	+19.5		401		
		−16.0	327.0	−20.0		62		
		−16.0	327.0	+18.0		432		
		−12.0	331.0	+7.5		46		
		+58.0	41.0	−19.0	8			
		+60.0	43.0	+17.0		15		
		+79.0	62.0	−24.0	62		1,103	

POSITIONS AND AREAS OF SUN SPOTS—Continued

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Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1936	h. m.	°	°	°				
Oct. 3	11 58	−48.0	281.2	−19.0		123		U. S. Naval.
		−35.0	294.2	+20.0		432		
		−29.0	300.2	−12.0	23			
		−5.0	324.2	+20.0		31		
		−3.0	326.2	−20.0		77		
		−2.0	327.2	+18.0		401		
		+2.0	331.2	+7.5		31		
		+40.0	9.2	+15.0		23	1,141	
Oct. 4	12 25	−34.0	281.8	−18.5		123		Do.
		−21.0	294.8	+20.5		525		
		−15.0	300.8	−12.0	15			
		+11.0	326.8	−19.5		46		
		+12.0	327.8	+17.5		278		
		+16.0	331.8	+8.0		31	1,018	
Oct. 5	11 56	−82.0	220.9	−12.0	93			Do.
		−55.0	247.9	+10.0	15			
		−23.0	279.9	−19.0		46		
		−15.0	287.9	−19.0		77		
		−8.0	294.9	+19.5		679		
		−1.0	301.9	−12.5	8			
		+24.0	326.9	+17.0		340		
		+27.0	329.9	−20.0		62		
		+29.0	331.9	+7.0	15		1,335	Do.
Oct. 6	13 12	−66.0	223.0	−13.0	216			
		−66.0	223.0	−20.0	62			
		−40.5	248.5	+10.0	15			
		−21.0	268.0	−28.5		46		
		−9.5	279.5	−19.5		31		
		0.0	289.0	−19.5		93		
		+6.0	295.0	+19.5		741		
		+39.0	328.0	+17.0		154		
		+41.0	330.0	−20.0		46	1,404	
Oct. 7	13 41	−62.5	213.0	−17.0	8			Do.
		−56.0	219.5	−20.0		62		
		−53.0	222.5	−12.5	231			
		−27.5	248.0	+10.0	15			
		−8.0	267.5	−28.0		46		
		+13.0	288.5	−19.0		108		
		+20.0	295.5	+19.5		648		
		+51.5	327.0	+17.0		108		
		+53.0	328.5	−20.0		93	1,319	
Oct. 8	11 2	−44.5	219.3	−20.5		77		Do.
		−41.0	222.8	−13.0	278			
		+3.0	266.8	−28.0		39		
		+27.0	290.8	−20.0		154		
		+32.0	295.8	+19.0		586		
		+65.0	328.8	+16.0		62		
		+66.0	329.8	−20.0		62	1,258	
Oct. 9	12 30	−40.0	209.8	+19.0	5			Mt. Wilson.
		−29.0	220.8	−20.0	75			
		−27.0	222.8	−14.0		368		
		−14.0	235.8	−36.0		61		
		+15.0	264.8	−28.0	5			
		+42.0	291.8	−20.0		42		
		+48.0	297.8	+19.0		601		
		+53.0	302.8	−12.0	5			
		+79.0	328.8	+15.0	16			
		+80.0	329.8	−21.0	128		1,306	
Oct. 10	17 45	−79.0	154.7	−18.0	268			Do.
		−40.0	193.7	−18.0		15		
		−12.5	221.2	−19.0		55		
		−10.0	223.7	−14.0	377			
		+1.0	234.7	−35.0		37		
		+60.0	293.7	−20.0		108		
		+65.0	298.7	+20.0		706		
		+70.0	303.7	−11.0		9	1,575	
Oct. 11	14 0	−71.0	151.6	−20.0		457		Do.
		−29.0	193.6	−18.0		13		
		−20.0	202.6	+32.0	12			
		−12.0	210.6	+18.0		43		
		−1.0	221.6	−20.0	64			
		+2.0	224.6	−14.0	365			
		+17.0	239.6	−33.0	10			
		+72.0	294.6	−20.0		30		
		+75.0	297.6	+20.0		814	1,808	
Oct. 12	11 44	−58.0	152.6	−19.0		300		U. S. Naval.
		+3.0	213.6	+19.0		93		
		+10.0	220.6	−20.0	31			
		+13.0	223.6	−13.0	247			
		+87.0	297.6	+20.0	278		958	
Oct. 13	11 39	−65.0	132.5	−19.0	8			
		−45.0	152.5	−19.0		216		Do.
		−3.0	194.5	−15.0		93		
		+19.0	216.5	+17.5	31			
		+21.5	219.0	+20.0	15			
		+23.0	220.5	−19.5	31			
		+26.5	224.0	−13.0	247		641	

POSITIONS AND AREAS OF SUN SPOTS—Continued

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POSITIONS AND AREAS OF SUN SPOTS—Continued

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Date	Eastern standard time	Heliographic			Area		Total area for each day	Observatory
		Diff. in longitude	Longitude	Latitude	Spot	Group		
1936	h. m.	°	°	°				
Oct. 14	11 26	−52.0	132.4	−18.5		93		U. S. Naval.
		−32.0	152.4	−19.5		247		
		+11.0	195.4	−15.5		216		
		+32.5	216.9	+18.0		154		
		+36.0	220.4	−20.0	31			
		+40.0	224.4	−14.0	278		1,019	
Oct. 15	11 45	−52.0	119.0	−12.0		66		Mt. Wilson.
		−37.0	134.0	−19.0		147		
		−17.0	154.0	−20.0		244		
		−14.0	157.0	+13.0		38		
		+26.0	197.0	−16.0		209		
		+45.0	216.0	+19.0		84		
		+50.0	221.0	−20.0		23		
		+53.0	224.0	−14.0	279		1,090	
Oct. 17	11 27	−74.0	70.9	+22.0		77		U. S. Naval.
		−69.0	75.9	+12.0		93		
		−22.0	122.9	−11.5		62		
		−15.0	129.9	−19.0		62		
		−8.0	136.9	−17.0	46			
		+9.0	153.9	−19.5		108		
		+16.5	161.4	+12.0	15			
		+51.0	195.9	−15.0		77		
		+82.0	226.9	−13.5	154		694	
Oct. 18	11 15	−56.0	75.9	+21.0		70		Harvard.
		−6.5	125.4	−12.5		64		
		+8.0	139.9	−17.0	79			
		+26.5	158.4	−18.0		235		
		+32.5	164.4	+12.0	30			
		+68.0	199.9	−14.5		139	617	
Oct. 19	11 15	−46.0	72.6	+21.5		62		U. S. Naval.
		+4.0	122.6	−12.0		93		
		+20.0	138.6	−19.5	39			
		+37.5	156.1	−20.0	93			
		+44.0	162.6	+10.5	31		318	
Oct. 20	11 10	−32.0	73.4	+21.0		46		Do.
		+17.0	122.4	−11.5		93		
		+34.5	139.9	−19.5		77		
		+50.0	155.4	−20.0	62		278	
Oct. 21	11 5	−75.0	17.3	+17.0		216		Do.
		−20.0	72.3	+21.0		46		
		+31.0	123.3	−11.0		77		
		+47.0	139.3	−19.5		154		
		+64.0	156.3	−20.0	46		539	
Oct. 22	11 11	−61.0	18.0	+17.0		247		Do.
		−7.0	72.0	+21.0		31		
		+45.0	124.0	−11.0		77		
		+62.0	141.0	−19.5		31		
		+79.0	158.0	−20.0	31		417	
Oct. 23	11 45	−44.0	21.5	+16.0		288		Mt. Wilson.
		−4.0	61.5	−26.0		29		
		+8.0	73.5	+22.5	5			
		+38.0	103.5	+19.0	21			
		+64.0	129.5	−12.0		20		
		+79.0	144.5	−19.0		15	378	
Oct. 24	11 38	−40.0	12.4	+17.5		62		U. S. Naval.
		−31.0	21.4	+16.0		154	216	
Oct. 25	12 48	−27.0	11.6	+17.5		46		Do.
		−18.0	20.6	+16.0		185	231	
Oct. 26	10 50	−85.0	301.5	+20.0	256			Mt. Wilson.
		−85.0	301.5	−25.0	21			
		−9.0	17.5	−14.0		207		
		−6.0	20.5	+17.0		235		
		+9.0	35.5	−25.0		10		
		+35.0	61.5	−23.0		2		
		+72.0	98.5	+19.5		14	745	
Oct. 27	11 12	−70.0	303.1	+20.0	123			U. S. Naval.
		−1.0	12.1	+17.0		31		
		+7.0	20.1	−16.0		77		
		+9.0	22.1	+16.0		123	354	
Oct. 28	11 8	−69.0	290.9	−20.0	46			U. S. Naval.
		−58.0	301.9	+19.5		247		
		−54.0	305.9	−25.0	31			
		+20.0	19.9	−16.0		46		
		+21.0	20.9	+16.0		123		
		+38.0	37.9	−25.0	15		508	
Oct. 29	11 17	−55.0	291.7	−20.0	62			Do.
		−45.0	301.7	+19.5		309		
		−40.0	306.7	−22.5	31			
		+35.0	21.7	+16.0	185			
		+48.0	34.7	−16.0	15			
		+51.0	37.7	−24.5	15		617	
Oct. 30	13 19	−65.0	267.4	−17.0		123		Do.
		−60.0	272.4	+20.0		46		
		−40.5	291.9	−20.5	39			
		−30.0	302.4	+19.0		216		
		−28.0	304.4	−25.0	15			
		+50.0	22.4	+15.0	93		532	
Oct. 31	11 19	−70.0	250.3	−17.0		93		Do.
		−53.0	267.3	−17.0		185		
		−47.0	273.3	+20.0		93		
		−29.0	291.3	−21.0	46			
		−20.0	300.3	+19.5		185		
		−16.0	304.3	−25.0	15			
		+62.0	22.3	+15.0		77	694	

Mean daily area for 30 days, 839.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS, OCTOBER 1936

[Data dependent alone on observations at Zurich and its station at Arosa]

[Furnished through the courtesy of Prof. W. Brunner, Eidgen, Sternwarte, Zurich Switzerland]

October 1936	Relative numbers	October 1936	Relative numbers	October 1936	Relative numbers
1	113	11	*ad* --	21	*d* 65
2	*Ec* 98	12	*Mac* 82	22	55
3	*Wac* 103	13	*a* 76	23	63
4	112	14	92	24	52
5	122	15	*WMcc*123	25	35
6	*bd* 129	16	*ad* 90	26	*Mc* 40
7	*Ec* --	17	105	27	*aad* 52
8	--	18	*a* 82	28	77
9	107	19	*a* 80	29	*d* --
10	81	20	85	30	95
				31	*d* 95

Mean, 27 days=85.5.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By LOYD A. STEVENS

Mean free-air temperatures and relative humidities for October, as determined from airplane weather observations, are given in table 1. The departures from normal given in the table are based on normals derived from the number of observations indicated in the note at the foot of the table, where the number of years during which the observations were taken are given by the figures in parentheses. In general, the numbers of observations available for computing the normals at the higher levels are less than those available for the lower levels (indicated in the footnote). To compensate for this discrepancy, the normals are computed by the method of differences.

The mean temperatures for the month at the surface were below normal, except over the southeastern portion of the country and at Lakehurst and Mitchel Field where above-normal temperatures prevailed. The greatest negative departures were −3.3° at Kelly Field and −2.1° at Fargo, while the greatest positive departures were +1.3° at Maxwell Field and +1.1° at Norfolk. Except over the northwestern part of the country (as shown by the records at Spokane, Wash.) the temperature conditions obtaining at the surface were in general duplicated at the successive upper levels. At Spokane, however, the negative departure of −0.4° at the surface was reversed at all upper levels to positive departures of from +2.1° to +2.5°. The greatest negative departure for all levels was −3.3° at Kelly Field at the surface, and the greatest positive departure was +3.1° at Mitchel Field at 4 km. The relatively large departure at Kelly Field, however, decreased gradually in value with height, becoming zero at 4 km and reversing to +0.7° at 5 km.

The mean relative humidities were above normal over the greater portion of the country at all levels; but several stations showed a reversal in sign with height, of the departure from normal. At Fargo a negative departure of 6 percent at the surface decreased to zero at 1.5 km, and was between +2 and +4 percent at all levels above 1.5 km. At Maxwell Field the departure was −1 percent at the surface; +2 and +1 percent, respectively, at 0.5 and 1 km; zero at 1.5 km; and then from −4 to −8 percent at all levels above 1.5 km. At Pensacola a similar change took place from +6 percent at the surface to −6 percent at 2,500 m. At Boston the departure was negative at all levels, except at 3 and 4 km where it was +3 percent and +6 percent, respectively. This station showed the greatest range in variation from the normal, from −10 percent at 1 km to +6 percent at 4 km. Spokane was the only station showing a negative departure at all upper levels; the maximum was −10 percent at 1.5 km.

It is interesting to note that this rather spotted condition in the indicated moisture content of the air coincided closely with the precipitation record over the country. For example, the greatest positive departure from the normal relative humidity at all levels was recorded at San Diego where it amounted to +15 percent at 3 km; over southern California, likewise, the most excessive rainfall was recorded, being one and one-half to four times the normal amount. One of the areas showing the greatest deficiency of rainfall was the northwest corner of the country, where, as previously mentioned, the Spokane upper air relative humidities were consistently below normal at all levels. A belt of below normal (25 to 50 percent) precipitation was recorded over the area from North Dakota and Minnesota south-southwestward to western Texas and New Mexico. This is no doubt due to the fact that a deficiency of moisture, as shown by the upper air relative humidity records, occurred at certain levels, usually near the surface, at all stations in this area. The marked deficiency of moisture in the upper levels at Maxwell Field coincided with the area over Mississippi and Alabama where a marked deficiency of precipitation was also recorded. Except over the States mentioned, precipitation above normal occurred over the greater portion of the area east of the Mississippi River, where the upper air relative humidities also were consistently above normal, especially in the lower levels.

The free-air resultant winds, based on pilot balloon observations made during the month of October, are given in table 2. At the surface and 0.5 km the most outstanding variation from the normal resultant direction occurred at San Diego where the resultant directions for the month were west and west-southwest in contrast with the normal directions of east-northeast and northwest, respectively. The unusual wind directions at these levels, together with the south wind at 1.5 km, no doubt contributed much to the excessive humidity and precipitation over southern California by bringing in an unusual amount of moisture laden air from the Pacific. At 0.5 km also, there is a definite shift of the resultant directions toward the south at Boston, Newark, and Washington, the variation from the normal being between 35° and 47°. At 1 km the same variation persisted at all three stations, but was less pronounced, the range being between 27° and 34°. These variations from the normal direction were apparently due to the marked intensification of several low pressure areas as they passed over or near the region contiguous to, and to the northeast of, the Great Lakes, and which therefore caused strong southerly or southwesterly winds to prevail at such times at these stations. Up to 1 km there was a distinct anticyclonic circulation centered approximately over northwestern Georgia, as indicated by both the current and the normal resultant wind directions. The southerly and southwesterly winds along the western and northern boundary of this area, composed for the most part of tropical maritime air, formed a definite front with the polar continental and polar Pacific air brought in by the northerly and northwesterly winds which obtained at Sault Ste. Marie, Omaha, Albuquerque, Cheyenne, and Fargo. The fluctuations of this front no doubt accounted in part for the above normal precipitation over the Ohio Valley, Arkansas, and east Texas. Another well marked front was indicated in the lower levels, by the resultant directions at Medford and Oakland, respectively, south-southeast to southwest winds prevailing at Medford and northwest to north-northeast at Oakland. This front also marked the boundary between the below-normal precipitation area to the north and the above-normal precipitation area to the south; the flow of air over Oakland apparently was predominantly of Pacific origin. Between 1.5 km and 4 km the most marked variation of the current monthly resultant directions from the normals occurred at stations along the Gulf and Pacific coasts. At Pensacola, the normal directions vary between north and northwest, while those for the current month were between west-southwest and west at these levels. A similar counter-clockwise variation from the normal occurred at Houston. At 4 km for example the normal direction is northwest (306°), while the direction for the current

month was west-southwest (257°). These variations were probably due to the frequent development of low-pressure troughs extending from the lower Mississippi Valley northeastward to the Ohio Valley, along which tropical air flowed from the Gulf of Mexico. The Pacific coast stations were rather irregular in their variation from normal resultant directions at 1.5, 2, and 2.5 km, but all showed a clockwise deviation at 3 km; the normal directions are between northwest and west, and those for the current month between north-northeast and north-northwest.

The resultant velocities were in general above normal over the eastern portion of the country, and below normal over the western portion. The greatest positive departure from normal (+4.1 m. p. s.) occurred at Sault Ste. Marie, at 3 km; and the greatest negative departure (−2.8 m. p. s.) at Medford at 3 km, and also at Salt Lake City at 4 km. This distribution of velocities coincided with the average movement of air masses during the month. There were, during the month, frequent outbreaks of polar continental air which moved at near normal speed down over the northern plains and eastern Rocky Mountain States and then increased in speed and, in some cases, in intensity, as they moved southeastward. The increased intensity of several low pressure areas in the region to the north and east of the Great Lakes, as previously mentioned, accounted, no doubt, for the high resultant velocities obtained at Sault Ste. Marie.

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during October 1936*

TEMPERATURE (° C.)

Stations	Altitude (meters) m. s. l. — Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		Number of observations
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Barksdale Field (Shreveport), La.[1] (52m)	14.0		16.9		14.2		12.7		11.0		9.0		7.1		1.1		−4.5		24
Billings, Mont.[2] (1,088 m)	6.7	−0.1					8.9	−0.7	7.0	−0.9	4.2	−0.9	1.2	−0.9	−4.6	0.0	−10.6	+0.4	31
Boston, Mass.[1] (5 m)	8.1	−1.9	7.9	−0.9	5.6	−1.2	3.8	−1.6	2.3	−1.6	0.4	−1.6	−1.9	−1.8	−7.2	−1.9	−12.9	−1.5	16
Cheyenne, Wyo.[2] (1,873 m)	3.4	−0.8							5.6	−0.7	5.1	−1.8	2.1	−2.0	−4.4	−1.5	−11.2	−1.1	31
El Paso, Tex.[2] (1,194 m)	12.7						15.5		14.1		11.3		8.1		0.9		−4.6		31
Fargo, N. Dak.[2] (274 m)	1.8	−2.1	4.3	−2.2	3.7	−2.7	2.1	−2.6	0.2	−2.5	−2.3	−2.6	−4.6	−2.5	−9.8	−2.4	−15.9	−2.5	30
Kelly Field (San Antonio), Tex.[1] (206 m)	13.2	−3.3	17.3	−2.1	16.8	−2.1	14.7	−1.6	13.0	−1.4	10.8	−1.2	8.3	−0.8	3.3	0.0	−2.7	+0.7	26
Lakehurst, N. J.[3] (39 m)	10.0	+0.9	10.3	+0.3	8.2	0.0	6.5	−0.4	4.7	−0.4	2.8	−0.1	0.9	+0.1	−4.1	+0.2	−8.0	+2.1	24
Maxwell Field (Montgomery), Ala.[1] (52 m)	17.0	+1.3	18.8	+0.3	16.6	+0.3	14.1	+0.3	12.8	+0.9	10.9	+1.1	8.5	+1.2	2.8	+1.7	−2.7	+2.7	30
Miami, Fla.[2] (4 m)	23.3		23.5		20.5		17.7		14.6		12.1		9.6		4.1		−2.0		31
Mitchel Field (Hempstead, L. I.), N. Y.[1] (29 m)	10.0	+0.9	10.4	+1.0	8.7	+1.2	7.2	+1.1	5.9	+1.5	3.9	+1.8	2.1	+2.1	−1.5	+3.1			23
Murfreesboro, Tenn.[2] (174 m)	12.4	+0.4	14.6	−0.3	13.2	−0.2	11.0	−0.2	9.0	0.0	7.3	+0.2	4.8	+0.2	−0.7	+0.4	−6.8	+0.3	31
Norfolk, Va.[3] (10 m)	15.4	+1.1	14.7	+0.9	12.0	+0.7	10.1	+0.6	8.0	+0.4	6.1	+0.5	3.8	+0.5	−1.9	−0.1	−7.6	0.0	24
Oakland, Calif.[2] (2 m)	12.7		16.6		17.9		15.3		12.9		9.5		6.6		0.3		−6.3		30
Oklahoma City, Okla.[2] (391 m)	11.1	−2.0	13.2	−1.6	13.0	−2.9	11.9	−2.4	10.7	−1.5	8.0	−1.5	5.0	−1.4	−1.2	−1.1	−6.7	−0.5	30
Omaha, Nebr.[2] (300 m)	8.0	−0.4	10.1	+0.2	10.1	−0.9	8.3	−1.2	6.4	−1.3	3.4	−2.0	1.0	−1.6	−5.2	−1.7	−12.1	−2.1	31
Pearl Harbor, Territory of Hawaii[3] (6 m)	23.0	−2.5	22.0	−0.4	18.7	+0.2	15.7	+0.2	13.6	+0.5	12.2	+0.7	9.7	+0.2	2.9	−0.5			30
Pensacola, Fla.[3] (13 m)	17.5	−0.5	19.5	+1.4	16.9	+1.0	14.6	+0.9	12.3	+0.6	10.4	+0.9	8.1	+1.0	2.3	+0.6	−2.8	+1.2	31
Salt Lake City, Utah[2] (1,288 m)	6.6						12.0		10.4		6.8		3.0		−3.7		−10.3		31
San Diego, Calif.[3] (10 m)	16.4	−1.0	17.1	−0.1	17.6	0.0	15.3	−0.5	12.1	−1.5	9.0	−1.9	6.1	−1.9	0.6	−1.4	−6.1	−1.6	30
Sault Ste. Marie, Mich.[2] (221 m)	3.6		3.3		1.1		−0.6		−2.0		−4.2		−6.4		−11.2		−16.4		30
Scott Field (Belleville), Ill.[1] (135 m)	9.4	+0.2	13.6	−0.3	13.0	0.0	10.8	0.0	8.4	−0.3	6.3	−0.5	3.6	−0.5	−2.5	−0.7	−8.7	−1.0	18
Seattle, Wash.[3] (10 m)	12.8		14.0		15.3		13.7		12.0		9.9		7.3		1.6		−4.4		5
Selfridge Field (Mount Clemens), Mich.[1] (177 m)	6.9	−0.4	8.1	−1.5	5.9	−2.0	4.1	−2.1	2.1	−2.1	−0.1	−2.2	−2.6	−2.2	−8.4	−2.4	−15.3	−3.2	31
Spokane, Wash.[2] (596 m)	5.8	−0.4			11.6	+2.1	10.9	+2.2	8.8	+2.3	6.3	+2.3	3.4	+2.1	−2.7	+2.2	−8.9	+2.5	31
Washington, D. C.[3] (13 m)	11.4	−0.6	12.4	+0.5	10.2	+0.3	8.6	+0.5	6.3	+0.2	4.3	+0.1	1.8	−0.3	−2.8	−0.2	−9.1	−0.8	29
Wright Field (Dayton), Ohio[1] (244 m)	9.2	+1.3	11.8	+1.0	9.8	−0.4	8.1	−0.3	5.8	−0.6	3.5	−0.8	1.3	−0.8	−3.8	−0.6	−11.3	−1.5	24

[1] Army. [2] Weather Bureau. [3] Navy.

RELATIVE HUMIDITY (PERCENT)

Stations	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Barksdale Field (Shreveport), La.	86		67		66		63		57		50		43		39		35		
Billings, Mont.	63	+1					54	+2	52	+3	53	+4	52	+3	47	−2	49	0	
Boston, Mass.	72	−2	59	−9	54	−10	55	−4	51	−4	46	−5	50	+3	50	+6	43	−1	
Cheyenne, Wyo.	68	+6							63	+5	56	+6	54	+7	51	+5	47	+1	
El Paso, Tex.	63						53		54		54		55		57		33		
Fargo, N. Dak.	67	−6	63	−3	57	−1	53	0	52	+3	52	+4	46	+2	47	+2	47	+4	
Kelly Field (San Antonio), Tex.	93	+2	70	−7	63	−3	59	−4	53	+1	47	+3	46	+6	38	+6	30	+3	
Lakehurst, N. J.	85	0	71	0	73	+4	67	+5	63	+8	58	+8	54	+8	45	+1	33	−5	
Maxwell Field (Montgomery), Ala.	83	−1	62	+2	60	+1	58	0	42	−8	35	−7	32	−5	30	−4	24	−7	
Miami, Fla.	93		83		79		72		69		61		55		46		39		
Mitchel Field (Hempstead, L. I.), N. Y.	86	0	76	+2	72	+2	70	+6	60	+4	57	+3	52	0	43	−4			
Murfreesboro, Tenn.	91	+6	74	+9	68	+7	63	+5	56	+3	46	0	43	−1	37	−4	33	−3	
Norfolk, Va.	84	+6	72	+4	68	+4	61	+4	58	+6	50	+4	43	+2	41	+6	39	+7	
Oakland, Calif.	82		64		42		35		32		32		31		32		31		
Oklahoma City, Okla.	83	0	73	−2	66	+4	61	+4	53	0	49	0	47	+1	44	−1	37	−1	
Omaha, Nebr.	77	−3	66	−5	60	+2	58	+4	52	+3	54	+7	49	+2	42	−2	42	0	
Pearl Harbor, Territory of Hawaii	88	+13	81	+5	81	+2	77	+3	69	+2	52	−2	42	−1	33	0			
Pensacola, Fla.	86	+6	71	0	68	0	64	+1	55	−1	44	−6	41	−4	39	0	31	−4	
Salt Lake City, Utah	66						50		48		50		52		52		49		
San Diego, Calif.	85	+10	74	+6	57	+7	52	+9	48	+12	48	+14	46	+15	36	+9	30	+7	
Sault Ste. Marie, Mich.	79		74		74		66		55		56		51		49		50		
Scott Field (Belleville), Ill.	92	+3	64	+4	58	+3	53	+2	52	+4	48	+5	44	+3	43	+2	40	+2	
Seattle, Wash.	87		68		48		41		36		33		35		38		38		
Selfridge Field (Mount Clemens), Mich.	87	+4	73	+4	70	+4	63	+4	55	+3	47	+1	45	+2	44	+3	41	+3	
Spokane, Wash.	80	0			55	−9	48	−10	47	−9	48	−7	49	−4	43	−6	39	−8	
Washington, D. C.	87	+11	66	+2	67	+5	62	+4	62	+7	52	+3	48	+3	36	0	33	+3	
Wright Field (Dayton), Ohio	91	+4	74	+3	69	+7	61	+6	60	+11	58	+12	49	+8	41	+3	38	+3	

Observations taken about 4:00 a. m., 75th meridian time, except along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—The departures are based on normals covering the following total number of observations made during the same month in previous years, including the current month (years of record are given in parentheses following the number of observations): Billings, 91 (3); Boston, 106 (5); Cheyenne, 93 (3); Fargo, 92 (3); Kelly Field, 80 (3); Lakehurst, 84 (3); Maxwell Field, 90 (3); Mitchel Field, 71 (3); Murfreesboro 93 (3); Norfolk, 171 (8); Oklahoma City, 92 (3); Omaha, 186 (6); Pearl Harbor, 161 (8); Pensacola, 209 (9); San Diego, 197 (8); Scott Field, 64 (3); Selfridge Field, 93 (3); Spokane, 91 (3); Washington, 249 (12); Wright Field, 84 (3). (Departures from normal for Seattle are omitted from this summary because of the paucity of observations.)

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during October 1936*—Continued

LATE REPORT FOR SEPTEMBER, 1936

TEMPERATURE (°C.)

Stations	Altitude (meters) m. s. l.																		
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		Number of observations
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Pearl Harbor, Territory of Hawaii [3] (6 m.)	23.4	−2.3	21.9	−0.4	18.3	−0.1	15.3	−0.1	13.3	+0.5	12.0	+0.8	9.7	+0.5	3.6	+0.1	−1.8	−0.2	30

RELATIVE HUMIDITY (PERCENT)

Pearl Harbor, Territory of Hawaii	84	+9	80	+3	84	+3	78	+2	69	0	52	−1	43	+2	33	0	11	−12	......

[3] Navy.

NOTE.—The departures are based on normals covering the following total number of observations made during the same month in previous years, including the current month (years of record are given in parentheses following the number of observations): Pearl Harbor, 154 (8). The observations are taken at dawn.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during October 1936*

[Wind from N=360°, E=90°, etc.]

Altitude (m) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (153 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (274 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Murfreesboro, Tenn. (180 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	356	1.9	356	1.2	259	2.9	253	1.6	294	3.2	243	1.1	257	0.4	240	1.8	285	0.9	13	1.3	62	1.9	168	0.6	172	0.8
500			32	2.9			256	7.3			253	6.3	241	4.3	256	5.5	286	2.6	106	1.1	74	3.2	221	.1	194	3.6
1,000			3	2.2			264	8.2			256	8.7	258	5.9	262	7.7	301	5.3	131	.3	94	2.7	215	.4	208	5.1
1,500			314	2.2	253	5.4	274	8.5			263	8.6	249	6.2	262	9.8	294	6.0	289	1.3	93	1.9	92	1.7	240	4.4
2,000	223	.8	283	4.8	286	5.6	284	8.8	294	5.1	275	9.6	259	9.0	259	11.4	291	10.1	277	2.9	94	1.4	61	3.7	253	4.0
2,500	226	3.1	273	6.0	296	6.5	288	10.8	299	7.0	270	12.0	265	8.7	265	11.1	287	8.8	290	3.3	84	1.5	31	3.9	271	5.1
3,000	259	4.6	263	5.4	299	7.7			311	7.6	283	11.5	246	7.4	255	9.9	298	9.2	306	4.2	92	1.5	32	5.2	275	3.8
4,000	258	6.2	276	5.4	303	9.8			303	8.1					264	10.8			257	6.1	281	1.1	344	4.7	224	4.9
5,000	276	8.0							296	5.7									288	5.2			346	5.1		

Altitude (m) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii [1] (68 m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	312	1.4	305	0.1	182	0.9	300	0.3	40	1.8	33	4.3	205	1.1	144	3.0	261	0.1	325	0.5	130	0.9	88	1.2	297	0.5
500	254	5.4	351	1.0	197	4.6	253	1.9	90	3.9	73	4.5	239	5.3			256	1.1	263	2.6	50	.6			258	3.8
1,000	273	6.7	22	2.9	232	5.8	273	4.1	87	4.2	56	.8	261	7.3			311	.7	272	7.5	201	.5	233	.8	266	4.9
1,500	280	8.4	44	2.8	250	4.6	284	6.3	81	1.9	250	1.5	263	6.3	144	2.7	186	1.0	278	10.5	270	1.4	267	2.6	271	5.8
2,000	275	9.3	96	1.7	263	4.1	286	7.9	94	1.2	246	2.6	264	7.0	180	.5	94	1.6	274	10.6	206	1.5	285	3.8	276	8.1
2,500	289	9.9	20	1.8	262	3.6	284	8.9	88	1.9	252	3.4	278	7.8	235	1.1	70	1.8	292	12.1	323	1.7	298	5.8	271	7.8
3,000			351	3.5	275	4.2	279	8.8	92	2.5	269	4.0	277	8.4	259	1.3	6	3.4	284	13.4	323	3.1	294	6.4	257	9.5
4,000					284	3.7	273	8.7	26	1.6	284	4.5	265	9.1	327	2.0	337	4.2					289	7.0		
5,000															326	4.3										

[1] Navy stations.

RIVERS AND FLOODS

[River and Flood Division, MONTROSE W. HAYES, in charge]

By BENNETT SWENSON

The floods of late September in the rivers in southeastern Texas continued into October. The Trinity River overflowed portions of Anderson and Leon Counties, causing property losses of approximately $21,500, but in the lower reaches flood stages were only slightly exceeded. The flood in the Brazos reached Valley Junction, Tex., on the 1st with a crest 3.6 feet above flood stage. Thereafter there was a rapid flattening out of flood water. Damage was confined principally to Washington and Robertson Counties where property (mostly matured crops) valued at $191,000, was destroyed. Although high stages occurred in the lower reaches of the Colorado, Guadalupe, and the Rio Grande Rivers the losses were relatively light because matured crops were mostly harvested, and highways damaged by an earlier flood were mostly unrepaired. Some flooding also continued in the Saluda, Santee, and Savannah drainage basins in South Carolina and Georgia with minor losses mostly to crops and livestock.

Rains set in on the 6th of the month and continued over much of the region east of the Mississippi River and also in Texas, becoming moderately heavy over the middle Mississippi Valley, the Ohio Valley, and the Atlantic States on the 9th, ending on the night of the 10th. Rains began again on the 15th in the Southeastern States, being moderately heavy over Virginia, the Carolinas, and Georgia, especially in the mountains, ending on the 17th.

On the 22d and 23d moderate rains occurred in the lower Ohio Valley, Arkansas, Oklahoma, and Texas, continuing in Texas until the 25th. Rather general rains occurred over the eastern half of the country on the 26th.

This series of rains caused distinct periods of floods in some sections of the country; and in other sections, especially in the Santee Basin, the river was above flood stage practically the entire month, and during a large portion of the month in the Saluda and Savannah drainage basins. Comparatively little property damage resulted from the floods in the Santee, Saluda, and Savannah Basins; however, the suspension of the logging industry in the vicinity of Rimini, S. C., on the Santee River, amounted to a wage loss of $16,700. Other rivers with one or more periods of floods during the month are as follows: James in vicinity of Columbia, Va., Neuse and Cape Fear in North Carolina, Peedee in South Carolina, Apalachicola in Florida, French Broad and tributaries in North Carolina, and Tennessee, minor tributaries of the Arkansas in Oklahoma and Arkansas, Sulphur in Texas, St. Francis in Missouri, Trinity and Colorado in Texas.

On the 16th and 17th a disastrous flood occurred in the upper reaches of the French Broad and tributaries, and the Broad and Catawba Rivers in North Carolina. Principal damage was to highways and bridges, estimated at $27,000. The high water was due to exceptionally heavy precipitation which fell in the mountains of western North Carolina. The following was reported from Asheville, N. C.:

Heaviest damage was along tributaries in Madison and Buncombe Counties; Henderson and Transylvania Counties suffered only slight damage. Rainfall for the storm averaged somewhat less than 3 inches at Hot Springs, Marshall, and Asheville (Madison and Buncombe Counties) and 3 to 4 inches at Hendersonville, Brevard, and Rosman (Henderson and Transylvania Counties). Precipitation usually averages 50 to 100 percent higher in the upstream counties than in the downstream area. The explanation, however, of the greater overflow and damage in Buncombe and Madison Counties may, perhaps, be found in such amounts as 8.69 inches at Point Lookout, a fire-weather substation near the crest of the Blue Ridge about 20 miles east of Asheville, and 8.63 inches at Mount Mitchell. These exceptionally large amounts from points just outside the eastern boundary of the drainage area of this French Broad district, most of which fell in 24 hours, should throw some light on the damage done along the upper reaches of the Broad, Catawba, and Nolichucky Rivers. The Cane and South Toe, tributaries of the Nolichucky, caused considerable damage; they drain either side of Mount Mitchell. Point Lookout, incidentally, is near Swannanoa Gap and has an elevation of only about 2,400 feet while Mount Mitchell rises to 6,684 feet above mean sea level.

Table of flood stages during October 1936

[All dates in October unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE	*Feet*			*Feet*	
James: Columbia, Va	10	17	19	15.1	18
Neuse:					
Smithfield, N. C	13	11	11	14.4	11
Goldsboro, N. C	13	4	5	13.2	5
		14	15	13.4	15
Kinston, N. C	13	17	18	13.4	17

Table of flood stages during October 1936—Continued

[All dates in October unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
	Feet			*Feet*	
Cape Fear: Lock No. 2, Elizabethtown, N. C	20	11	12	21.8	11
Peedee:					
Cheraw, S. C	30	10	10	33.6	10
		18	19	33.5	19
Mars Bluff Bridge, S. C	17	12	15	17.9	14
		19	26	19.7	23
Poston, S. C	18	24	28	18.9	26
Saluda:					
Pelzer, S. C	6	Sept. 30	2	13.5	Sept. 30
		8	12	11.0	10
		17	18	6.3	17, 18
Chappells, S. C	15	2	3	17.6	3
		9	13	18.1	12
		17	19	18.7	18
Broad: Blairs, S. C	14	1	1	15.2	1
		9	11	18.4	10
		17	19	24.0	18
Congaree: Columbia, S. C	19	19	19	20.6	19
Catawba:					
Catawba, N. C	8	16	19	16.7	17
Catawba, S. C	11	10	10	11.0	10
		17	18	13.6	18
Wateree: Camden, S. C	23	----------	----------	22.8	19
Santee:					
Rimini, S. C	12	2	(1)	17.6	22
Ferguson, S. C	12	5	(1)	14.0	23, 24
Broad: Carlton, Ga	15	Sept. 30	1	24.7	1
		9	10	16.4	10
Savannah:					
Calhoun Falls, S. C	8	1	1	9.0	1
Ellenton, S. C	14	2	8	21.2	4
		10	21	23.5	13
		----------	----------	16.3	19
Clyo, Ga	13	10	14	14.0	11, 12
		16	24	16.6	18
EAST GULF OF MEXICO DRAINAGE					
Apalachicola: Blountstown, Fla	15	10	14	15.9	11
MISSISSIPPI SYSTEM					
Ohio Basin					
Pigeon: Newport, Tenn	6	16	17	11.0	17
Nolichucky: Embreeville, Tenn	8	16	16	8.9	16
French Broad:					
Oldtown (near Newport, Tenn.)	6	16	18	10.8	16
Dandridge, Tenn	12	17	17	12.3	17
Asheville, N. C	6	9	10	6.2	9
		16	17	9.0	16
Arkansas Basin					
Verdigris: Sageeyah, Okla	35	10	·2	35.8	11
Poteau: Poteau, Okla	21	26	28	25.6	27
Petit Jean: Danville, Ark	20	28	28	20.4	28
Red Basin					
Sulphur: Ringo Crossing, Tex	20	24	24	20.0	24
		26	27	23.1	26
Lower Mississippi Basin					
St. Francis: Fisk, Mo	20	11	11	20.3	11
WEST GULF OF MEXICO DRAINAGE					
Elm Fork: Carrollton, Tex	6	Sept. 28	1	9.4	Sept. 28, 29
		26	27	7.1	26
Trinity:					
Dallas, Tex	28	Sept. 27	2	35.2	Sept. 28
		26	29	29.4	27
Trinidad, Tex	28	Sept. 29	10	36.0	1
		30	Nov. 2	28.7	Nov. 1
Long Lake, Tex	40	4	10	43.5	5
Liberty, Tex	24	16	18	24.1	16, 17
Brazos: Valley Junction, Tex	44	Sept. 30	1	47.6	1
Colorado:					
Marble Falls, Tex	21	Sept. 27	3	[2] 28.0	Sept. 27
Mud, Tex	25	2	2	28.5	2
Austin, Tex	21	----------	----------	20.6	2
Columbus, Tex	24	Sept. 29	5	35.4	1
Wharton, Tex	26	Sept. 19	7	36.9	3
Guadalupe:					
Gonzales, Tex	20	Sept. 29	1	29.9	Sept. 30
Victoria, Tex	21	1	5	26.7	
Rio Grande:					
Mercedes, Tex	21	2	2	21.3	
Brownsville, Tex	18	Sept. 29	5	19.7	2

[1] Continued into November.
[2] Estimated.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. Tannehill in charge]

NORTH ATLANTIC OCEAN, OCTOBER 1936

By H. C. Hunter

Atmospheric pressure.—The pressure averaged considerably below normal over the waters near Greenland and Iceland; Julianehaab, Greenland, averaged almost a quarter-inch below normal. Elsewhere pressure averaged slightly to considerably above normal, with the greatest excess from the Azores northeastward to the Bay of Biscay and the waters round Ireland.

The northeasternmost part of the ocean had higher pressure than normal practically throughout the first 12 days of October, and mainly lower pressure afterward, save near Ireland. On the other hand, the record of Horta shows practically all of the pressure readings that were either below or close to normal occurred during the first 12 days.

The extreme pressures so far reported from vessels are 30.69 and 28.61 inches. The higher reading was noted on the Dutch motorship *Drechtdijk*, during the forenoon of the 14th, near 42° N., 22° W.; the lower reading was made on the Swedish motorship *Blankaholm*, about 8 a. m., on the 26th, near 58° N., 20° W. Julianehaab, Greenland, recorded even lower pressure on the 28th.

Table 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, October 1936*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.50	−0.24	29.98	7	28.40	28
Reykjavik, Iceland	29.57	−.11	30.09	7, 9	28.76	24
Lerwick, Shetland Islands	29.82	+.03	30.39	9	28.62	27
Valencia, Ireland	30.09	+.18	30.42	11, 12	29.53	26
Lisbon, Portugal	30.13	+.11	30.39	27	29.80	5
Madeira	30.09	+.10	30.33	14	29.83	17
Horta, Azores	30.29	+.18	30.60	24	29.98	1
Belle Isle, Newfoundland	29.86	.00	30.56	24	28.90	27
Halifax, Nova Scotia	30.10	+.06	30.58	15	29.46	18
Nantucket	30.08	+.03	30.58	14	29.27	17
Hatteras	30.08	+.02	30.38	31	29.50	17
Bermuda	30.10	+.03	30.24	4	29.84	18
Turks Island	29.96	+.01	30.04	10	29.89	18
Key West	29.95	+.01	30.10	24	29.81	17
New Orleans	30.04	+.01	30.31	30	29.85	10

Note.—All data based on a. m. observation only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—There were many reports of gales, apparently more than usual during October, but comparatively few of these reports indicated force 10 (whole gale) or greater.

During the first 3 days, strong to whole gales were noted in midocean and thence eastward to the waters near Ireland. Then, about the 13th, a very intense storm, advancing down the St. Lawrence Valley and thence northeastward to southern Greenland, caused winds of hurricane strength to northeastward of Belle Isle, as noted on the British steamship *Helmstrath*.

Over the waters just east of the United States coast the most important period of gales during the month was connected with a storm that was central over Georgia on the morning of the 16th, with only moderate energy. There was a marked increase in strength during the movement of the center northeastward over the Atlantic States and Labrador till it reached the vicinity of Godthaab, Greenland, late on the 19th. The American tanker *A. C. Bedford*, about 350 miles east of the Virginia Capes, recorded wind of force 11 during the afternoon of the 17th. The American freight steamship *Edwin Christenson*, on a short coastwise run, with only a light load remaining, was caught the same day not far from the shore of Long Island and narrowly escaped being blown aground. The great British liner *Queen Mary*, westbound, was in a very heavy beam sea for 4 hours early on the 18th, when less than a day's run east of New York Harbor.

To the northward of the forty-fifth parallel, from midocean eastward to the North Sea, the final week of October witnessed vigorous storm activity. The American steamship *Bessemer City* noted force 12 wind on the 26th, in the Irish Sea, while the Swedish motorship *Blankaholm* encountered like strength of wind on the same day, when well west of Scotland, and again on the 29th, when near 55° N., 30° W. Considerable loss of life in European waters because of the intense gales of this week is indicated by press dispatches.

From the southeastern part of the North Atlantic Ocean, reports come of brief wind storms near the Guinea coast during the nights of 12–13th and 14–15th. These were of the violent type that blow from the east or southeast, and are styled "tornadoes" by mariners accustomed to traversing those waters.

Fog.—There was considerably less fog than there had been during September just preceding; and on the whole there was less fog than normally occurs during October, especially over the eastern and central parts of the North Atlantic, where several squares, even to northward of the forty-fifth parallel, furnished no reports at all.

The waters near the Grand Banks and the coast of Nova Scotia had more fog than most other areas; the square 45° to 50° N., 45° to 50° W., led in occurrence, with 10 days. Near Nova Scotia and thence southwestward to Delaware Bay, fog was almost limited in occurrence to the days from 7th to 11th, inclusive. To southward of Hatteras no fog was reported.

OCEAN GALES AND STORMS, OCTOBER 1936

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began October	Time of lowest barometer October	Gale ended October	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Arizpa, Am. S. S.	Panama City, Fla.	Liverpool	44 15 N.	43 57 W.	[1] 29	4a, 1	2	29.80	NW	WNW, 9	NW	WNW, 10	NW-WNW-NW.
Sagaporack, Am. S. S.	Copenhagen	Norfolk	54 00 N.	36 25 W.	1	10a, 1	2	28.65	NW	S, 5	NW	NNW, 10	S-NW.
Volendam, Du. S. S.	Rotterdam	New York	[2] 49 40 N.	34 54 W.	[1] 29	10a, 1	2	28.95	SE	SW, 8	SW	SW, 10	
Tennessee, Dan. S. S.	Copenhagen	do	[2] 53 59 N.	36 21 W.	[1] 29	1p, 1	2	28.87	ESE	S, 9	NW	ESE, 10	SSE-WNW.
Tactician, Br. S. S.	Cristobal	Vera Cruz	19 21 N.	95 30 W.	3	1a, 3	4	29.87	NW	NW, 7	NE	NW, 7	NW-NE.
American Banker, Am. S. S.	New York	London	50 02 N.	12 40 W.	3	11a, 3	3	29.60	SE	SSE, 8	SSE	SSE, 9	SSE-S.
Wacosta, Am. S. S.	Mobile	Bremen	49 46 N.	10 49 W.	3	11a, 3	4	29.73	SE	SE, 10	SE	SE, 10	None.
Yaka, Am. S. S.	Antwerp	Mobile	46 10 N.	23 04 W.	7	2p, 7	8	29.72	SSW	SSW, 7	NNW	WNW, 9	SSW-WNW.
Belgian Gulf, Belg. M. S.	Port Arthur	Antwerp	45 45 N.	33 15 W.	7	2p, 7	8	30.15	NW	NW, 8	NW	NW, 9	None.
San Antonio, Fr. S. S.	Havre	Curacao	45 00 N.	12 50 W.	8	2p, 8	9	29.46	SE	NNW, 8	NNW	NNW, 10	SE-NNW.
Mercier, Belg. S. S.	Buenos Aires	Antwerp	[2] 39 56 N.	12 44 W.	11	6a, 10	12	[3] 29.79	NE	NW, 5	NE	NE, 9	NW-NE.
Helmstrath, Br. S. S.	Swansea	Montreal	54 12 N.	36 45 W.	9	10a, 10	10	[3] 29.48	SW	S, 5	WNW	S, 9	S-WNW.
Sunetta, Du. M. S.	Curacao	Lisbon	32 12 N.	36 54 W.	11	2p, 12	15	29.33	NNW	NNW, 7	SE	E, 10	NNW-NE.
Cathlamet, Am. S. S.	Dakar	Conakry	13 10 N.	17 24 W.	13	3a, 13	13	29.93	SE	SE, 9	SE	SE, 9	
Helmstrath, Br. S. S.	Swansea	Montreal	53 08 N.	49 50 W.	11	4a, 13	16	[3] 29.18	SSW	SW, 8	WSW	WSW, 12	SW-WSW.
Cathlamet, Am. S. S.	Dakar	Conakry	9 35 N.	14 33 W.	14	10p, 14	14	29.95	ENE	ESE, 8	SE	ESE, 8	ENE-SE.
Badjestan, Br. S. S.	Buenos Aires	Sydney	[2] 29 13 N.	48 31 W.	15	Mdt, 14	16	29.75	NE	N, 6	NE	NE, 8	NNW-NE.
Irisbank, Br. M. S.	Gibraltar	Halifax	39 43 N.	45 54 W.	15	4p, 15	16	[3] 29.77	N	N, 8	N	N, 10	NE-N.
Black Hawk, Am. S. S.	Antwerp	New York	50 30 N.	35 50 W.	16	11p, 15	16	29.51	NW	SE, 4	NW	NW, 9	SE-W-NW.
Minnequa, Am. S. S.	Philadelphia	Miami	36 37 N.	75 12 W.	16	4a, 17	17	29.54	SE	S, 7	SSW	SE, 8	SE-SSW.
Laurent Meeus, Belg. M. S.	Houston	Amsterdam	[2] 40 05 N.	37 40 W.	15	1p, 17	18	29.68	N	NNW, 10	S	NNW, 10	NNW-SW.
A. C. Bedford, Am. S. S.	Halifax	Texas City	37 18 N.	70 17 W.	16	2p, 17	18	29.34	SSW	E, 11	W	E, 11	SSE-NE-E.
Irisbank, Br. M. S.	Gibraltar	Halifax	44 13 N.	62 16 W.	18	Noon, 18	18	[3] 29.30	SSE	SSE, 6	S	SSE, 9	
Badjestan, Br. S. S.	Buenos Aires	Sydney	[2] 43 04 N.	56 38 W.	18	4p, 19	19	29.87	SW	Var, 2	SSW	S, 9	N-W.
Jean Jadot, Belg. S. S.	Antwerp	New York	50 14 N.	35 43 W.	21	10a, 21	21	[3] 29.76	W	WNW, 5	NW	W, 9	S-W-NW.
Georgia, Dan. S. S.	New York	Oslo	57 50 N.	6 15 E.	22	8a, 25	25	29.19	SW	SW, 8	SSW	SW, 11	SW-SSW.
Blankaholm, Swed. M. S.	Gothenburg	Portland, Maine.	57 37 N.	19 47 W.	25	8a, 26	27	28.61	WSW	WSW, 6	WNW	WNW, 12	SW-W-NNW.
Black Gull, Am. S. S.	Rotterdam	Boston	49 00 N.	26 00 W.	25	6a, 26	26	29.88	W	W, 9	WNW	W, 9	W-WNW.
Scanstates, Am. S. S.	Copenhagen	New York	58 30 N.	9 06 W.	26	Noon, 26	28	28.88	WNW	SW, 4	NW	NW, 10	WNW-SW-NW.
Brandywine, Am. S. S.	Galveston	Boston	42 08 N.	70 05 W.	26	6p, 26	26	29.76	NW	NW, 8	N	N, 9	W-N.
Bessemer City, Am. S. S.	Colon	Liverpool	53 00 N.	5 14 W.	26	8p, 26	27	29.24	WSW	W, 11	NW	W, 12	None.
Spaarndam, Du. S. S.	Rotterdam	New York	45 05 N.	57 49 W.	27	4a, 27	27	29.36	S	SW, 8	NW	WNW, 9	S-WNW.
Blankaholm, Swed. M. S.	Gothenburg	Portland, Me.	55 55 N.	26 45 W.	27	8a, 28	29	29.16	S	SSW, 7	WSW	SW, 12	SSW-WSW.
Monarch of Bermuda, Br. S. S.	Bermuda	New York	35 06 N.	67 36 W.	29	6a, 29	29	29.68	SW	SW, 9	NW	SW, 9	SW-NW.
Leerdam, Du. S. S.	New York	Rotterdam	41 30 N.	57 23 W.	29	11p, 29	30	29.09	ESE	N, 10	NNW	N, 10	NE-NNW.
Black Gull, Am. S. S.	Rotterdam	Boston	45 18 N.	49 42 W.	30	10a, 30	30	29.04	SE	SSW, 10	WNW	SW, 10	SE-SW.
Volendam, Du. S. S.	do	New York	48 21 N.	44 40 W.	30	10p, 30	31	29.51	SSE	S, 10	SW	S, 10	S-SW.
Blankaholm, Swed. M. S.	Gothenburg	Portland, Maine.	52 06 N.	42 22 W.	30	4a, 31	31	29.24	SE	SSW, 10	WSW	SSW, 10	SE-W.
Scanstates, Am. S. S.	Copenhagen	New York	55 24 N.	33 06 W.	30	Noon, 31	31	29.44	W	SW, 9	WSW	S, 10	SSE-WSW.
NORTH PACIFIC OCEAN													
Pres. Jefferson, Am. S. S.	Victoria, B. C.	Yokohama	[2] 52 05 N.	166 48 W.	1	4a, 1	1	[3] 28.86	NW	SSE, 6	NW	NW, 9	SSE-NW.
Hikawa Maru, Jap. M. S.	Vancouver	do	[2] 52 05 N.	147 47 W.	2	6a, 2	3	29.05	SW	SE, 5	W	W, 8	SE-NNW-SW.
Bessemer City, Am. S. S.	Los Angeles	Balboa	12 04 N.	89 57 W.	2	Mdt, 2	3	29.73	NE	NE, 10	NE	NE, 10	E-NE.
Pres. Pierce, Am. S. S.	Honolulu	Yokohama	33 03 N.	148 05 E.	3	11p, 3	4	29.51	S	SW, 9	W	SW, 9	S-SW.
San Pedro Maru, Jap. M. S.	San Francisco	do	35 45 N.	142 00 E.	3	4p, 3	3	28.09	SSE	Calm	NNW	W, 10	E-Calm-W.
Pres. Jefferson, Am. S. S.	Victoria, B. C.	do	46 47 N.	160 00 E.	5	8p, 5	6	29.02	WSW	SW, 10	NW	WSW, 10	SW-WSW.
Koyo Maru, Jap S. S.	Yokohama	Port San Luis	[2] 38 55 N.	179 54 W.	7	2p, 6	6	29.58	WNW	WNW, 8	WNW	WNW, 8	
Steelmaker, Am. S. S.	Hilo	Balboa	13 40 N.	104 05 W.	6	6p, 6	7	29.77	W	WSW, 8	SSW	SW, 9	
San Diego Maru, Jap. M. S.	Amoroo	Yokohama	43 58 N.	168 10 E.	6	Noon, 6	7	29.38	W	W, 8	WNW	W, 8	
Silverguava, Br. M. S.	Cebu, P. I.	Portland, Oreg.	40 10 N.	170 22 E.	6	4a, 7	7	29.88	WNW	W, 9	NW	W, 9	None.
Cingalese Prince, Br. M. S.	Balboa	Los Angeles	13 22 N.	94 48 W.	7	9p, 7	8	29.77	W	W, 7	NW	W, 7	W-WNW.
Washington, Fr. M. S	do	do	20 10 N.	106 15 W.	7	5p, 8	8	29.61	SE	SE, 7	NNW	SE, 7	SE-NNW.
Hanover, Am. S. S	Los Angeles	Balboa	20 30 N.	106 30 W.	7	5a, 8	9	29.68	NE	ESE, 7	ESE	ESE, 8	E-ESE.
General Lee, Am. S. S	Portland, Oreg	Yokohama	48 25 N.	168 15 E.	9	2p, 9	10	29.34	ESE	SE, 7	NNW	W, 9	ESE-SE-W.
Hanover, Am. S. S	Los Angeles	Balboa	13 42 N.	95 30 W.	11	6p, 11	12	29.80	ENE	NE, 7	N	NE, 7	ENE-N.
Illinois, Am. S. S	Manila	San Francisco	[2] 44 32 N.	148 44 W.	12	Mdt, 11	13	29.35	SW	S, 6	NW	SW, 8	S-SW.
Pres. McKinley, Am. S. S.	Yokohama	Victoria, B. C.	50 04 N.	140 45 W.	12	2p, 12	14	29.28	SSW	S, 5	SSW	SSW, 8	S-SW.
Pres. Jackson, Am. S. S	Seattle	Yokohama	52 20 N.	144 20 W.	13	1a, 13	13	29.04	NNE	ENE, 4	N	NNE, 8	E-N.
San Ramon Maru, Jap. M. S.	Kobe	San Francisco	44 52 N.	171 42 W.	13	2p, 13	14	28.98	NE	NNE, 8	N	NNE, 9	NE-N.
Oregon Maru, Jap. S. S.	Yokohama	do	43 51 N.	178 02 E.	14	Mdt, 14	15	29.82	N	ENE, 3	N	N, 9	ENE-N.
Pres. Jackson, Am. S. S.	Seattle	Yokohama	52 08 N.	159 46 W.	14	2p, 14	15	28.97	ESE	S, 8	WNW	ESE, 9	S-NW.
Heian Maru, Jap. M. S.	Yokohama	Vancouver	48 38 N.	164 21 W.	14	Mdt, 14	15	29.28	N	N, 8	N	N, 8	Steady.
Heiyo Maru, Jap. M. S.	Los Angeles	Yokohama	41 57 N.	160 51 E.	15	1a, 16	17	29.00	SE	WSW, 8	N	S, 9	SW-W.
Ramapo, U. S. N.	Yokohama	San Diego	40 06 N.	172 12 W.	15	Noon, 17	15	29.04	S	SSW, 5	SSW	SSW, 8	S-SSW.
Athelcrown, Br. M. S.	Kobe	Los Angeles	44 42 N.	169 42 W.	15	1p, 17	17	29.22	SE	E, 5	ESE	ESE, 8	
Hoyeisan Maru, Jap. S. S.	Singapore	Keelung	23 20 N.	123 08 E.	13	8p, 17	19	[3] 29.65	NNW	NE, 8	N	N, 9	
Falsterbo, Swed. M. S.	Balboa	Portland, Oreg.	34 28 N.	120 34 W.	20	Noon, 18	21	29.78	N	Calm	N	N, 10	
Kirishima Maru, Jap. M. S.	Yokohama	Los Angeles	34 25 N.	168 58 E.	18	4a, 20	20	29.66	S	NW, 7	N	W, 8	S-N.
Getsuyo Maru, Jap. M. S.	Osaka	Portland, Oreg.	44 06 N.	160 50 E.	21	11p, 21	22	29.21		N, 11		N, 11	
General Sherman, Am. S. S.	Yokohama	San Francisco	40 20 N.	151 30 E.	20	3a, 21	21	28.89	ENE	NNE, 9	NNW	NNW, 10	ENE-NNW.
Pres. Jackson, Am. S. S.	Seattle	Yokohama	42 48 N.	151 30 E.	21	4a, 21	21	29.24	ENE	NE, 10	N	NE, 10	ENE-N.
Ramapo, U. S. N.	Yokohama	San Diego	40 03 N.	153 46 W.	20	4a, 21	21	29.53	SSE	SSE, 9	SSE	SSE, 9	None.
San Pedro Maru, Jap. M. S.	Osaka	San Francisco	43 17 N.	176 16 W.	21	3a, 22	23	28.54	SW	SW, 6	WNW	WNW, 9	SW-W.
Pres. Grant, Am. S. S.	Yokohama	Victoria	[2] 47 46 N.	172 18 E.	21	9a, 22	23	29.04	E	NE, 10	NNW	NE, 10	E-NE.
General Sherman, Am. S. S.	do	San Francisco	43 11 N.	162 52 E.	23	Noon, 23	23	29.47	SSE	SSE, 8	S	SSE, 8	SSE-S-SW.
Pres. Harrison, Am. S. S.	Honolulu	Kobe	34 14 N.	148 07 E.	27	1p, 27	27	29.78	S	S, 9	S	S, 9	S-SSW.
Naruto Maru, Jap. M. S.	Los Angeles	Balboa	19 45 N.	105 51 W.	27	Mdt, 27	28	29.61	ENE	SE, 8	S	SE, 8	E-S.
Hikawa Maru, Jap. M. S.	Yokohama	Vancouver	47 21 N.	170 41 E.	27	Mdt, 28	29	28.84	SSE	SW, 8	WSW	SW, 8	SW-W.
San Antonio, Fr. S. S.	Balboa	Los Angeles	[2] 14 31 N.	93 42 W.	30	8a, 30	30	29.82	N	N, 3	NNE	NNE, 7	Calm-N-NNE.
Hikawa Maru, Jap. M. S.	Yokohama	Vancouver	50 19 N.	153 32 W.	31	8p, 31	31	29.47	ESE	SSE, 8	SSE	SE, 9	SE-SSE.

[1] September. [2] Position approximate. [3] Barometer uncorrected.

NORTH PACIFIC OCEAN, OCTOBER 1936

By J. H. GALLENNE

Atmospheric pressure.—Pressures averaged high during October over the ocean region adjacent to the coast between Juneau, Alaska, and Tatoosh Island, Wash.; the maximum plus departure of 0.12 inch was noted at the latter place.

With the exception of 9 days during the month, low pressure predominated over the Aleutians. In this area, Dutch Harbor recorded the greatest minus departure for the month, −0.15 inch. Elsewhere over the ocean, near normal pressures prevailed.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, October 1936, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	29.97	+0.04	30.48	18	29.56	16, 22
Dutch Harbor	29.50	−.15	30.10	17	28.84	1
St. Paul	29.59	−.04	30.22	18	29.12	20
Kodiak	29.62	+.03	30.22	18	28.70	5
Juneau	29.98	+.11	30.41	31	29.38	5
Tatoosh Island	30.13	+.12	30.50	15	29.74	29
San Francisco	29.96	−.05	30.17	26	29.70	16
Mazatlan	29.85	+.01	29.94	29	29.70	8
Honolulu	29.96	−.04	30.06	3	29.72	29
Midway Island	30.02	−.01	30.30	27	29.76	19
Guam	29.82	−.02	29.92	16	29.72	10
Manila	29.76	−.04	29.90	3	29.44	11
Hong Kong						
Naha	29.86	−.04	30.16	27	28.80	1
Chichishima	29.91	.00	30.22	28	29.48	12
Urakawa	29.90		30.28	28	28.72	3

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Cyclones and gales.—There was much stormy weather, and gales were frequent over the ocean during October. Cyclonic conditions were charted some distance southeast of Naha on the first of the month, moving in a northeasterly direction. Naha reported wind, northeast, force 9; barometer 28.80 inches at the morning observation. At about noon of the 3d, the motorship *San Pedro Maru*, encountered this disturbance, giving her position then as 36°03′ N., and 141°59′ E. This same vessel subsequently reported, from 2 to 3:55 p. m., wind southeast to east, increasing to force 10, with heavy rain. Between 3:55 and 4:05 p. m., the wind abated suddenly and blue sky was observed. Shortly after passing from the calm center, a westerly wind developed to force 10 until 7 p. m., accompanied by heavy rain. The barometric minimum 28.09 inches (corrected) was observed at about 4 p. m. This is the lowest pressure of record during the month over the North Pacific Ocean.

Strong gales prevailed for the first 3 days of the month, north of the 50th parallel, between 140° and 170° west longitude.

On the morning of the 7th, the center of a weak cyclonic circulation was noted at approximately 15° N. and 105° W., moving in a north-northwesterly direction. The available reports do not show definite progressive movement after October 9, at which time this tropical disturbance was located over the Gulf of California. In connection with this disturbance, the steamship *Steelmaker*, near latitude 14° N. and longitude 102° W., at 7 a. m. of the 7th, reported fresh south-southwest gales and at 7 p. m. of the 8th, the steamship *Hanover*, near 20° N. and 106° W., noted wind southeast, force 8; barometer 29.73 inches.

The center of a vigorous depression was charted at the p. m. observation of the 12th near latitude 42° N. and longitude 179° W., moving in a direction slightly south of east. On the morning of the 13th the steamship *Winamac*, 41½° N. and 170° W., then northwest of the center, reported wind northeast, force 10; barometer 28.82 inches. Increasing in intensity, this depression curved toward the northwest and was centered at about 42½° N. and 170° W. at the p. m. observation of the 13th. Further reports from the steamship *Winamac*, during the p. m. of the 13th, stated position approximately 41½° N. and 172° W.; wind northwest, force 12; barometer 28.79 inches. During the next 2 days, this depression decreased in intensity and moved along a north-northeasterly course. It passed inland about 150 miles west of Kodiak, Alaska, during the afternoon of the 15th. Several vessels encountering this disturbance reported strong gales. (See table of Gales and Storms.)

During the period October 17 to 20, gales of force 8 to 12 occurred in the Far East in connection with typhoons. A report of typhoons of the Far East by the Rev. Bernard F. Doucette, S. J., of the Central Observatory, Manila, P. I., appears elsewhere in this REVIEW.

At 4 p.m. of the 20th the motorship *Falsterbo*, near latitude 41°02′ N. and longitude 124°50′ W. reported north wind, force 10. This vessel at that time was in the easterly quadrant of an anticyclonic area.

Strong anticyclonic conditions overspread the lower central and western portions of the Pacific Ocean from the 26th to the 29th of the month.

At the a.m. observation of the 27th, an area of low pressure was noted near 12½° N. and 106° W. From ship reports at noon of the same day, it was evident that a tropical disturbance was centered near 15° N. and 105° W. At that time the steamship *Capella* near latitude 19°05′ N. and longitude 108°20′ W. reported, "northeast wind of force 6; barometer 29.92 inches and falling; wind increasing, very rough sea and heavy swell." At latitude 18°11′ N. and 105°32′ W. the steamship *Japanese Prince* reported wind southeast 7; barometer 29.68 inches; rain; heavy confused swell and sea. With the exception of an observation from the steamship *Antigua*, near latitude 19° N. and 106° W. at 7 p.m. of the 27th, reporting wind force 7 and torrential rain, little is known further of the life of this depression until the morning of the 28th, when reports show that it had developed to full hurricane intensity. At 7 a.m. of the 28th, the hurricane center could be fixed near latitude 20°22′ N. and longitude 106°38′ W., by the report received from the steamship *Edward Luckenbach:* "Latitude 20°22′ N., longitude 106°38′ W., wind south-southeast 12, barometer 28.78 inches. Center of disturbance of hurricane force, wind shifted to northwest, force 12."

Winds of force 12 were also reported on the morning of the 28th by the steamship *Japanese Prince* and the motorship *Annie Johnson* near the path of this disturbance.

At 7 a.m. of the 29th a LOW (29.83 inches) was charted near 32½° N. and 119° W. This appears to have been the remnant of the tropical disturbance.

Tehuantepecers.—"Norther" type gales were reported in the Gulf of Tehuantepec, as follows: Of force 9 on the 4th and 5th; and of force 10 on the 3d.

Fog.—Fog was observed over some portions of the coastal area between Vancouver Island, B. C., and Lower California, every day during the first 2 weeks of the month. Thereafter only a few fog reports on scattered days were noted, and these were observed mostly along the American coast south of the fiftieth parallel.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST, OCTOBER 1936

By Rev. BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Four typhoons and two depressions occurred during October 1936 over the regions of the Far East. Of these storms, the most noteworthy is the typhoon (Oct. 7 to 16) which formed in the Pacific Ocean, moved across Luzon and reversed its course just after entering the China Sea.

Typhoon, September 25 to October 4.—A depression appeared in the Pacific about 500 miles east of northern Luzon, moved slowly northwest, recurved to the northeast and was located September 28 about 700 miles east of Formosa. Thus far it had manifested no signs of great intensity, but as it turned westward it became very severe. The morning of October 1 found it about 90 miles south-southwest of Naha recurving sharply to the northeast. It moved rapidly along this course, changing to the north-northeast as it touched the coast of central Japan, passing close to and south of Tokyo. No complete reports of the damage resulting from this typhoon reached Manila newspapers. Naha reported, October 2, 6 a. m., a barometer of 738 mm (29.005 inches), with west-northwest winds, force 8, as the typhoon center was about 60 miles north-northeast of the station.

Typhoons, October 7 to 16.—An extensive low pressure trough reaching from the Philippines to the eastern Caroline Islands finally developed into two typhoons, one near the Philippines, the other over the Pacific Ocean, between Guam and Yap. These two disturbances are described as follows:

The most important of these storms, because of its peculiar course, appeared as a depression, about 500 miles east by north of Manila, and moved northwest, then west, intensifying on the evening of October 7 into a typhoon. The morning of the 9th, the typhoon was close to and south of Echague, Isabela Province, gradually inclining to the west-southwest. Its motion now was decreasing, probably due to the rough mountainous country over which it was passing, as its course lay to the southeast of Baguio, Mountain Province, and Dagupan, Pangasinan Province. The morning of October 10 it was located near or over the coast line. From this point, it moved very slowly west and the next morning, it had reversed its course, after moving southward for a while. It crossed the northern part of Zambales Province, moving eastward (Oct. 11) and was located about 60 miles north of Manila on the morning of October 12. It changed to the north-northeast, at the same time moving more rapidly. It shifted to the northeast as it entered the Pacific, and slight traces of its existence were found until October 16.

The reversal of the course on October 11 was due to the rapid building up of an anticyclone over China. The strong northeasterly winds over Formosa Channel and the northern China Sea, together with the rising pressures reported from Chinese stations, gave indications that the westward motion of the typhoon would certainly be checked, so that, when the storm appeared to be stationary throughout October 10, the easterly course was not unexpected.

There were two minima reported from stations along the course of this typhoon, those of October 9 being the lower. The lowest value reported was that at Echague, October 9, 5:45 a. m., namely, 731.98 mm (28.818 inches) with northwest winds force 8. Dagupan, on October 9, 4:45 p. m., recorded a value of 738.30 mm (29.067 inches) with winds force 4. The stations at Tuguegarao, Cagayan Province, Vigan, Ilocos Sur Province, San Fernando, La Union Province, Olongapo and Iba, Zambales Province, Baler and Infanta, Tayabas Province, and Manila reported values between 740 mm and 750 mm (29.134 inches and 29.528 inches). These values are corrected for gravity.

Great destruction resulted as this typhoon moved across Luzon on its west-southwest course, October 9. The rains caused extensive floods which did great damage to property and was the cause of the loss of many lives, a total of 517 dead being published in the newspapers of October 16. The provinces of Nueva Ecija and Zambales suffered the most. The typhoon fortunately was very much weakened as it moved eastward across Luzon and very little damage occurred after October 11.

The steamship *Chicago Maru* passed through the typhoon center October 11, 4 a. m., latitude 15°45′ N., longitude 119°15′ E., experiencing northwest winds force 3 and a barometric minimum of 29.10 inches, (739.14 mm). The sea was very high but not confused, stars were visible, and birds covered the rigging of the ship. Before the ship reached the center (the ship was en route to Manila, southerly course), while under the influence of the north-quadrant winds, very little rain fell, but after passing into the region of the southwest winds, gusty rain squalls with thunder and lightning were experienced. The same day, but late in the afternoon, the steamship *Phemius* left Manila but, on entering the China Sea, found such a high sea with hurricane winds, that she returned to her anchorage. Because of this adverse weather just outside Manila Bay, many ships were delayed and could not enter port until the typhoon had weakened and moved away.

Simultaneously with this typhoon, another disturbance had formed and was following its course far away over the Pacific Ocean. Forming between Guam and Yap, it moved west-northwest for 4 days, and then recurved to the north-northeast near latitude 17° N., longitude 129° E., on the forenoon of October 11. Changing to the northeast it moved rapidly toward the Bonin Islands. When about 90 miles west of these islands, it again moved on a north-northeast course proceeding to the one hundred and fiftieth meridian, which it crossed October 14.

Typhoon, October 13 to 21.—A depression appeared northeast of Guam, moved west-northwest for 1 day, intensifying as it proceeded. It then moved west until the afternoon of October 15, then west by north, to latitude 17°30′ N., longitude 132° E. There it took a north-northwest course and approached Naha. When about 60 miles south-southeast of this island (Oct. 18, afternoon), it sharply recurved to the northeast, moving even more rapidly than before. Two days later the typhoon was beyond the 150th meridian.

On October 14 and 15, the steamship *Corabank* was under the influence of this typhoon. The typhoon approached the vessel, passed close to and south of her position, October 15, 1000 Greenwich mean time. The ship was then near latitude 17°10′ N., longitude 136°50′ E., the position given at 1230 Greenwich mean time. The lowest value of pressure reported by the ship was 29.20 inches (741.68 mm) October 15, 0700 Greenwich mean time at latitude 16°50′ N., longitude 136°30′ E., with tendency to fall. The steamship *Marthara* reported October 16, 0000 Greenwich mean time from latitude 20° N., longitude 136° E., northeast gales, precipitous sea from the northeast, barometer 29.53 inches (750.06 mm) falling. These radio reports give an indication of the intensity and rapidity of movement of this disturbance.

Depression, October 22 to 27.—A depression moved rapidly northwest from a position about 200 miles south-southeast of Guam. On the 24th and 25th it proceeded more slowly and then recurved near latitude 20°, longitude 130° (Oct. 26) and disappeared October 27 between Japan and the Bonins.

Depression, October 25 to 28.—A depression, apparently of minor importance, was central in latitude 17° N., longitude 131° E., on October 25. It moved northwest for 1 day, recurved to the northeast, and was lost October 28, probably having filled up.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, October 1936

[For description of tables and charts, see REVIEW, January, p., 29]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	67.1	+2.4	Thomasville	94	8	2 stations	30	31	2.12	−0.90	Riverton	10.09	Lock no. 1	0.00
Arizona	63.5	+.3	2 stations	106	[1] 10	do	20	[1] 20	.81	−.02	Junipine	3.72	3 stations	.00
Arkansas	61.1	−1.5	Crossett	93	5	Eureka Springs	24	27	5.00	+1.83	Lutherville	8.65	Rogers	2.98
California	61.4	+.9	Palm Springs	109	[1] 11	Portola	12	5	1.22	−.01	Mount Wilson	6.44	5 stations	.00
Colorado	46.3	−.4	Cheyenne Wells	90	12	Pearl	−3	22	1.17	.00	Hawthorne	3.25	Buena Vista	.06
Florida	75.6	+2.5	Cedar Keys	99	6	Vernon	38	31	5.50	+1.24	Fort Pierce	16.41	Belle Glade	1.65
Georgia	67.2	+2.3	2 stations	93	1	2 stations	28	31	3.87	+1.10	Brunswick	8.65	Sparta	1.09
Idaho	48.2	+1.2	2 stations	89	[1] 9	Obsidian	−1	[1] 28	.33	−1.14	Lifton	1.83	19 stations	.00
Illinois	55.4	+.3	Harrisburg	88	19	Freeport	16	27	3.23	+.48	Carbondale	6.79	Keithsburg	.78
Indiana	55.1	+.3	Shoals	87	[1] 6	La Porte	17	27	4.44	+1.67	Seymour	7.50	Evans Landing	2.62
Iowa	50.9	−.6	Guthrie Center	88	18	Rock Rapids	10	26	1.69	−.68	Fairfield	6.76	Inwood (near)	.15
Kansas	55.2	−1.7	Phillipsburg	92	12	Oberlin	12	22	1.82	−.14	Sedan	7.16	Norton	.33
Kentucky	58.5	+.3	Pikeville	88	[1] 8	Anchorage	24	27	3.47	+.74	Maysville	6.12	Glasgow	1.87
Louisiana	68.2	−.2	New Orleans, no. 2	95	6	Tallulah	33	30	2.22	−1.01	Robeline	5.91	2 stations	.40
Maryland-Delaware	57.7	+1.6	Cumberland, Md	85	20	2 stations	16	28	3.24	+.22	Emmitsburg, Md	6.02	Solomons, Md	.81
Michigan	46.7	−2.4	St. Ignace	82	6	Dukes	4	27	3.03	+.19	Roscommon (near)	4.98	Calumet	.64
Minnesota	42.5	−3.8	Wheaton	88	8	Roseau	−16	26	.68	−1.25	Albert Lea	2.96	Gonvick	T
Mississippi	66.1	+.7	Kosciusko	96	6	2 stations	31	31	1.76	−.85	Booneville	7.56	Kipling	T
Missouri	56.7	−.7	Nevada	89	5	do	20	27	3.55	+.63	Dean	8.87	Memphis	1.01
Montana	46.5	+1.9	2 stations	89	[1] 8	Outlook	−7	22	.89	−.43	Red Lodge (near)	2.39	Dillon	T
Nebraska	50.3	−1.2	Alma	92	12	Gordon	0	22	.38	−1.12	Pawnee City	2.46	2 stations	.00
Nevada	52.8	+2.4	Logandale	98	[1] 9	Beowawe	12	[1] 28	.76	+.20	Sharp	2.93	do	.00
New England	49.4	−.1	Turner Falls, Mass.	83	[1] 9	Somerset, Vt.	7	28	4.54	+1.02	Lincoln, N. H.	6.97	Block Island, R. I.	2.08
New Jersey	55.6	+.9	Burlington	82	22	Layton	9	28	3.40	−.01	Ridgefield	4.84	Bridgeton	1.80
New Mexico	52.2	−1.4	Carlsbad	95	20	Therma	11	7	.60	−.53	Gavilan (near)	2.46	3 stations	.00
New York	50.4	+.4	3 stations	81	[1] 20	Indian Lake	6	28	4.54	+1.23	Salisbury	9.74	Dansville	1.49
North Carolina	62.5	+2.5	Goldsboro	89	7	Banners Elk	22	31	6.11	+2.73	Tryon	14.25	Parker	2.05
North Dakota	42.3	−1.2	2 stations	90	8	4 stations	−5	[1] 21	.21	−.88	Pembina	.83	Ashley	.00
Ohio	54.2	+.8	Gallipolis (near)	88	6	Holgate	18	28	4.00	+1.42	Cambridge	9.16	Cleveland	1.78
Oklahoma	59.2	−3.0	Altus	92	19	2 stations	22	27	2.91	−.09	Tulsa	7.11	Kenton	.25
Oregon	51.3	+1.7	Powers	103	9	Austin	0	31	.13	−1.75	Tillamook	1.74	23 stations	.00
Pennsylvania	54.0	+1.5	Meadville	87	7	Gouldsboro	11	28	3.69	+.49	Natrona	6.13	Philadelphia Navy Yard.	1.30
South Carolina	65.8	+2.1	Beaufort (near)	93	24	Chester	26	31	6.14	+3.08	Caesars Head	15.07	Edgefield	1.86
South Dakota	47.5	−1.0	Faith	91	8	2 stations	−3	26	.40	−.80	Faith	1.58	Pollock	T
Tennessee	60.8	+.8	Union City	87	19	Dover	27	28	4.02	+.96	Coldwater	7.18	New Tazewell	1.99
Texas	63.6	−4.1	Alice	99	9	2 stations	25	[1] 26	2.44	−.32	Honey Grove	6.76	Presidio	.00
Utah	49.3	+.4	Hanksville	95	8	Woodruff	14	29	1.64	+.55	Alton	3.35	Salina	.18
Virginia	59.5	+2.1	Diamond Springs	88	10	Big Meadows	19	28	3.66	+.72	North River Dam	7.49	Walkerton	1.02
Washington	52.8	+3.2	Kosmos	94	10	Pomeroy	11	21	.69	−2.43	Wishkah Headworks.	5.02	5 stations	.00
West Virginia	56.5	+1.9	2 stations	89	[1] 9	Alpena	12	28	3.89	+1.08	Pickens	7.50	Roanoke	2.07
Wisconsin	44.9	−3.2	Grantsburg	83	8	Laona	2	23	2.26	−.21	Shawano	4.73	Mondovi	.35
Wyoming	43.4	.0	Cody	87	11	Hunter's Station	−5	22	1.01	−.08	Middle Forks	4.31	Deaver	.20
Alaska (September)	45.0	+.1	Treepoint	79	30	Fort Yukon	7	14	3.09	−.71	Little Port Walter	20.73	Fort Yukon	.14
Hawaii	74.9	+1.2	Waimanalo	94	[1] 15	Kanalohuluhulu	44	5	10.64	+5.14	Piihonua	30.00	Ka Lae	.33
Puerto Rico	77.0	−.8	2 stations	96	[1] 4	Guineo Reservoir	45	[1] 17	7.83	−.38	La Mina (El Yunque).	37.17	Central San Francisco.	.85

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, October 1936*

[Compiled by Annie E. Small, by official authority, U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation: Thermometer above ground	Elevation: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	°F.		°F.	° F.		°F.	° F.	° F.	° F.	%	In.	In.		Miles								0-10	In.	In.
New England							51.5	+0.5										76	3.67	+0.4										5.4		
Eastport	76	67	85	29.96	30.05	+0.05	47.4	−0.1	68	8	54	22	27	41	27	45	43	87	3.32	−0.2	13	8,200	sw.	39	s.	18	8	8	15	6.2	T	0.0
Greenville, Maine	1,070	6	40	28.85	30.03	------	42.8	------	70	22	52	17	27	34	28	----	----	----	6.37	------	13	4,997	se.	30	-----	12	8	8	15	----	T	.0
Portland, Maine	103	82	117	29.94	30.06	+.02	50.4	+.5	75	8	59	25	27	42	32	44	37	66	2.94	−.2	11	6,738	sw.	38	s.	17	19	6	6	3.5	0.0	.0
Concord	289	60	----	29.64	30.06	+.01	49.4	−.3	79	21	61	16	28	38	40	----	----	----	4.72	+1.9	8	------	ne.	----	-----	----	11	12	8	----	.0	.0
Burlington	403	11	48	29.58	30.03	−.01	48.0	−1.2	74	22	56	22	28	40	31	43	39	75	4.75	+1.8	15	8,584	s.	35	nw.	12	9	8	14	6.0	.1	.0
Northfield	876	12	60	29.09	30.06	+.02	45.6	+.1	78	21	57	12	28	34	39	41	38	80	4.30	+1.4	13	5,969	s.	26	sw.	12	9	6	16	6.3	T	.0
Boston [1]	29	31	50	30.04	30.07	+.02	54.4	+.8	79	21	63	25	27	46	29	48	43	72	2.67	−.5	8	7,443	sw.	38	se.	17	13	7	11	5.1	.0	.0
Nantucket	12	14	90	30.07	30.08	+.03	55.0	+.8	71	8	61	32	27	49	23	51	47	79	4.28	+.9	12	10,736	sw.	40	se.	17	10	7	14	5.8	.0	.0
Block Island	26	11	46	30.05	30.08	+.03	55.2	+.3	70	8	60	29	27	50	26	52	49	81	2.08	−1.5	9	11,319	s.	55	se.	17	10	9	12	5.5	.0	.0
Providence	160	215	251	29.91	30.09	+.04	54.0	+1.8	76	8	62	25	27	46	30	48	44	73	2.49	−.6	8	7,516	nw.	51	se.	17	15	6	10	4.5	.0	.0
Hartford	159	70	104	29.90	30.08	+.02	53.2	+2.0	78	8	62	24	28	44	34	----	----	----	3.69	+.2	9	5,724	s.	27	nw.	30	13	6	12	5.2	.0	.0
New Haven	106	74	153	29.98	30.10	+.04	54.2	+.4	75	8	62	25	28	46	29	49	45	73	5.10	+1.4	9	6,699	n.	30	se.	17	10	7	14	5.8	.0	.0
Middle Atlantic States							58.0	+1.6										76	3.00	0.0										5.4		
Albany	97	97	112	29.96	30.07	+.01	52.2	+.1	78	21	61	22	28	43	31	47	42	74	3.99	+1.3	13	5,562	s.	27	sw.	26	13	5	13	5.4	T	.0
Binghamton	871	57	79	29.13	30.07	+.01	51.6	+1.6	79	20	61	20	28	42	33	----	----	----	3.48	+.5	14	4,724	nw.	25	nw.	30	3	9	19	7.5	T	.0
New York	314	415	454	29.76	30.09	+.03	57.0	+.7	75	21	64	27	27	50	29	51	47	73	4.05	+.5	9	10,662	sw.	52	nw.	30	11	7	13	5.5	.0	.0
Harrisburg	374	94	104	29.70	30.10	+.02	55.9	+1.1	77	20	64	26	28	47	30	50	45	73	2.00	−.9	10	5,182	w.	28	nw.	30	13	4	14	5.5	T	.0
Philadelphia	114	174	367	29.99	30.12	+.05	58.6	+.8	78	22	67	29	27	50	26	52	48	73	1.76	−1.0	8	8,764	sw.	34	nw.	26	11	8	12	5.4	.0	.0
Reading	323	283	306	29.75	30.11	------	56.8	+2.1	80	20	65	24	28	48	29	50	45	71	2.18	−.9	10	8,060	s.	41	se.	17	11	8	12	5.2	.0	.0
Scranton	805	72	104	29.22	30.08	+.01	52.6	+.7	78	21	61	21	28	44	34	47	42	73	2.11	−.9	13	4,594	sw.	26	nw.	12	6	12	13	6.0	T	.0
Atlantic City	52	37	172	30.04	30.10	+.03	59.4	+2.5	74	8	66	31	27	53	32	55	52	78	2.30	−.9	10	10,972	se.	59	e.	17	10	6	15	5.7	.0	.0
Sandy Hook	22	10	57	30.07	30.09	------	57.9	+1.0	75	10	64	31	27	52	28	53	49	78	3.77	.0	11	10,241	s.	43	nw.	30	13	4	14	5.4	.0	.0
Trenton	190	88	106	29.90	30.10	------	56.4	+.8	79	22	65	27	27	48	30	51	46	76	2.76	.0	8	6,572	s.	30	nw.	30	12	7	12	5.2	.0	.0
Baltimore	123	100	215	29.98	30.11	+.03	60.0	+1.8	81	22	68	30	28	52	29	53	49	71	1.73	−1.2	9	7,340	sw.	38	se.	17	14	5	12	5.0	.0	.0
Washington	112	62	85	29.98	30.10	+.02	59.7	+2.3	83	8	69	27	28	51	28	53	49	75	1.70	−1.1	7	4,755	nw.	29	nw.	30	12	7	12	5.1	.0	.0
Cape Henry	18	8	54	30.08	30.10	------	64.8	+2.7	81	8	70	41	27	59	25	60	57	80	5.88	+2.9	8	9,428	sw.	37	nw.	30	13	9	9	4.7	.0	.0
Lynchburg	686	5	----	29.38	30.12	+.03	60.8	+2.3	86	8	73	23	28	49	37	----	----	----	3.93	+.8	9	------	sw.	----	-----	----	8	17	6	----	.0	.0
Norfolk	91	80	125	30.02	30.12	+.05	65.0	+2.5	83	7	72	41	27	58	24	59	56	79	5.31	+2.3	11	6,971	e.	28	se.	16	10	11	10	5.5	.0	.0
Richmond	144	11	52	29.97	30.12	+.04	61.8	+2.2	84	8	72	29	31	51	30	55	52	80	1.68	−1.2	5	5,550	sw.	24	nw.	30	16	6	9	4.5	.0	.0
Wytheville	2,304	49	55	------	30.10	+.01	56.2	+2.6	77	8	66	29	31	47	35	----	----	80	2.44	−.4	10	4,242	w.	24	nw.	30	10	9	12	----	.0	.0
South Atlantic States							67.1	+2.8										81	5.47	+2.2										5.0		
Asheville	2,253	89	104	27.78	30.12	+.03	58.5	+3.2	77	22	68	29	31	49	35	53	50	80	3.85	+1.1	11	5,876	se.	24	ne.	16	9	11	11	5.8	.0	.0
Charlotte	779	63	86	29.28	30.12	+.04	63.8	+2.1	83	23	73	38	28	55	26	57	53	77	6.10	+3.2	9	4,569	ne.	18	sw.	7	11	9	11	5.3	.0	.0
Greensboro [1]	886	6	56	29.16	30.12	------	60.6	------	80	23	71	29	31	50	33	55	53	88	2.99	------	7	5,272	ne.	26	nw.	17	9	11	11	5.4	.0	.0
Hatteras	11	5	50	------	30.08	+.02	69.4	+3.5	82	8	74	47	31	65	16	64	62	82	5.00	.0	13	10,748	ne.	37	s.	16	13	7	11	5.1	.0	.0
Raleigh	376	103	146	29.70	30.10	+.03	63.6	+1.6	83	22	73	38	28	55	26	58	55	79	3.61	+.8	10	6,165	ne.	27	nw.	17	18	7	6	3.8	.0	.0
Wilmington	72	73	107	30.02	30.10	+.04	67.4	+2.1	84	22	76	40	31	59	28	61	59	82	7.15	+3.9	10	6,497	ne.	30	sw.	11	14	7	10	4.6	.0	.0
Charleston	48	11	92	30.02	30.07	+.01	67.6	+2.6	87	1	77	48	28	64	22	65	62	82	5.55	+2.3	9	8,254	ne.	31	nw.	14	13	5	13	5.1	.0	.0
Columbia, S. C.	347	70	91	29.72	30.10	+.03	67.2	+2.9	84	8	76	43	31	58	27	60	56	76	4.72	+2.2	8	5,828	ne.	24	ne.	27	16	5	10	4.2	.0	.0
Greenville, S. C.	1,039	139	----	------	------	------	63.4	+3.2	81	25	72	40	28	55	28	----	----	----	6.07	+3.0	8	------	ne.	----	-----	----	12	7	12	----	.0	.0
Augusta	182	62	77	29.88	30.07	.00	69.0	+3.7	88	8	78	42	31	60	30	61	58	78	3.11	+.6	7	4,306	ne.	21	se.	8	13	7	11	5.1	.0	.0
Savannah	65	73	152	29.99	30.06	+.01	71.7	+3.8	89	1	80	48	30	63	26	65	63	84	2.43	−.6	9	7,648	e.	27	e.	14	11	9	11	5.1	.0	.0
Jacksonville	43	86	110	29.99	30.04	+.02	73.2	+2.1	88	1	80	53	28	66	21	68	66	86	12.62	+8.2	15	5,866	ne.	23	e.	14	8	9	14	6.0	.0	.0
Florida Peninsula							79.7	+2.9										79	4.69	−1.1										4.5		
Key West	22	10	64	29.93	29.95	+.01	81.4	+2.3	91	11	87	70	19	76	17	75	73	78	3.80	−2.2	14	5,942	ne.	24	se.	7	15	12	4	3.9	.0	.0
Miami	25	124	168	29.94	29.97	.00	80.2	+3.2	89	2	86	70	30	75	18	74	72	79	7.59	−.8	15	6,771	ne.	23	se.	7	11	11	9	5.0	.0	.0
Tampa	35	88	197	29.96	30.00	+.02	77.4	+3.1	89	2	85	58	31	70	23	70	68	81	2.67	−.4	8	7,968	ne.	30	sw.	11	13	11	7	4.5	.0	.0
Titusville	43	5	36	29.94	29.99	------	75.9	------	90	1	83	58	30	68	23	----	----	----	5.97	------	20	------	n.	----	-----	----	10	12	9	----	.0	.0
East Gulf States							68.8	+2.0										78	2.59	−0.3										4.4		
Atlanta [1]	976	5	53	29.06	30.08	+.01	64.4	+1.4	83	8	73	40	31	56	28	58	56	85	3.61	+1.0	10	5,547	ne.	24	nw.	16	10	8	13	5.6	.0	.0
Macon	370	79	87	29.68	30.07	+.01	67.9	+3.4	86	23	78	42	31	58	30	61	59	81	2.33	.0	8	4,874	n.	20	nw.	17	13	10	8	4.5	.0	.0
Thomasville	273	49	58	29.76	30.05	+.01	71.2	+3.0	88	7	80	49	30	62	28	65	62	82	5.25	+2.3	6	------	ne.	----	-----	----	10	11	10	----	.0	.0
Apalachicola	35	11	----	29.99	30.03	------	73.4	+2.8	90	1	80	53	30	66	21	67	65	81	4.46	+1.3	8	6,157	n.	26	s.	8	14	9	8	4.2	.0	.0
Pensacola	56	149	185	29.99	30.05	+.02	71.7	+1.8	86	1	79	51	28	65	23	65	62	76	4.18	.0	5	8,190	ne.	24	n.	27	18	9	4	3.4	.0	.0
Anniston	741	9	----	------	------	------	64.8	+2.4	82	21	74	35	31	55	35	----	----	----	1.56	−1.1	8	------	se.	----	-----	----	12	10	9	----	.0	.0
Birmingham	700	11	48	29.31	30.08	+.01	66.2	+1.4	85	22	77	43	29	56	30	58	55	77	1.64	−.8	9	4,932	n.	18	se.	31	14	8	9	4.5	.0	.0
Mobile	57	86	105	29.98	30.04	.00	70.9	+1.6	88	8	81	46	31	61	31	63	60	77	.42	−3.2	8	6,109	n.	24	n.	27	14	10	7	4.1	.0	.0
Montgomery	218	92	105	29.83	30.08	+.02	69.0	+2.4	88	7	78	46	31	60	28	61	58	76	2.45	.0	6	4,916	n.	19	nw.	26	14	8	9	4.6	.0	.0
Meridian	375	67	92	29.67	30.06	.00	66.5	+2.2	89	6	79	39	30	54	39	58	54	72	.08	−2.3	3	3,861	n.	17	nw.	17	16	7	8	4.0	.0	.0
Vicksburg	247	65	73	29.82	30.08	+.01	66.4	−.3	87	25	77	44	27	56	33	58	55	75	1.60	−1.2	6	4,839	n.	19	w.	7	17	8	6	4.8	.0	.0
New Orleans	53	76	84	29.99	30.04	+.01	72.8	+1.8	88	6	80	53	28	66	22	65	61	74	3.49	+.2	6	4,991	ne.	17	n.	27	16	8	7	3.9	.0	.0
West Gulf States							65.4	−2.5										59	2.63	−0.5										4.4		
Shreveport	249	92	227	29.81	30.08	+.03	65.5	−1.1	90	5	76	44	27	55	30	57	52	70	4.09	+1.4	6	7,319	ne.	46	nw.	25	18	3	10	4.1	.0	.0
Bentonville	1,303	12	38	28.70	30.08	+.03	57.6	−.4	81	19	67	34	27	48	32	----	----	----	4.13	+.6	8	4,636	s.	19	sw.	31	11	8	12	5.9	.0	.0
Fort Smith	457	79	94	29.58	30.07	+.02	61.6	−1.2	87	19	77	39	29	52	34	54	50	73	4.03	+1.0	8	5,356	e.	21	nw.	17	14	6	11	4.7	.0	.0
Little Rock	357	94	102	29.70	30.08	+.02	62.2	−1.4	85	5	72	36	27	52	32	55	50	73	4.42	+1.7	5	5,620	e.	22	nw.	25	14	6	11	4.8	.0	.0
Austin	605	136	148	29.43	30.06	------	64.8	−3.5	88	19	75	43	27	54	31	57	53	75	2.63	−.6	8	5,132	n.	30	nw.	6	16	3	12	4.3	.0	.0
Brownsville	57	88	96	29.93	29.99	------	71.0	−3.9	88	18	79	51	27	63	27	64	62	82	.61	−2.7	8	7,261	nw.	27	nw.	7	16	3	11	5.4	.0	.0
Corpus Christi	20	11	78	30.01	30.03	+.03	70.5	−2.7	88	6	78	51	27	62	28	64	61	79	.95	−1.5	6	7,139	n.	29	e.	14	11	8	12	4.2	.0	.0
Dallas	512	220	227	29.51	30.06	------	62.6	------	88	19	72	38	27	54	30	55	51	72	2.89	+.2	7	7,639	se.	29	w.	6	16	5	10	4.3	.0	.0
Fort Worth	679	92	110	29.26	30.08	+.05	62.6	−4.1	88	19	72	37	27	53	33	----	----	----	3.72	+.9	7	6,338	s.	28	s.	20	17	5	9	3.9	.0	.0
Galveston	54	106	114	29.99	30.05	+.02	70.9	−1.8	87	17	77	51	28	65	22	65	62	77	1.68	−2.7	3	7,295	n.	25	nw.	7	16	8	7	3.7	.0	.0
Houston	138	292	314	29.91	30.06	------	68.4	−1.9	88	6	77	48	28	60	33	----	----	----	1.06	−2.7	3	8,512	n.	34	nw.	7	14	8	9	4.2	.0	.0
Palestine	510	64	72	29.55	30.08	+.05	63.9	−3.3	88	19	74	41	30	54	31	56	52	74	3.36	.0	3	4,735	s.	24	nw.	25	18	0	13	4.4	.0	.0
Port Arthur	34	58	66	30.01	30.05	------	69.4	------	88	5	78	49	28	60	26	62	59	78	1.31	−2.1	3	5,551	n.	21	n.	26	17	7	7	3.9	.0	.0
San Antonio	693	242	301	29.32	30.04	+.03	66.3	−4.2	89	18	76	42	27	57	27	58	53	70	1.89	−.3	9	7,581	n.	50	nw.	6	18	2	11	4.0	.0	.0

[1] Observations taken at airport.

TABLE I.—*Climatological data for Weather Bureau stations, October 1936*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F.		° F.	° F.		° F.	° F.	° F.	° F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							**58.2**	**+0.4**										**76**	**3.72**	**+1.0**										**5.6**		
Chattanooga	762	71	214	29.29	30.10	+0.01	64.2	+2.3	84	8	74	40	31	55	30	57	53	74	3.95	+0.9	9	5,083	ne.	24	nw.	17	11	10	10	5.1	0.0	0.0
Knoxville	995	66	84	29.05	30.11	+.02	62.0	+2.1	83	8	72	39	31	52	31	55	52	79	2.06	−.6	11	3,860	ne.	18	w.	9	13	7	11	4.9	.0	.0
Memphis	399	78	86	29.66	30.08	+.01	62.6	−.7	83	4	71	38	27	54	25	55	51	73	3.39	+.7	8	5,310	e.	21	n.	26	14	6	11	4.9	.0	.0
Nashville	546	168	188	29.53	30.12	+.04	61.0	.0	81	5	70	36	29	52	31	54	50	75	3.38	+.9	8	5,973	nw.	26	s.	31	10	8	13	5.9	.0	.0
Lexington	989	6					57.7	+.3	84	9	69	26	28	46	33				2.80	−.2	10		n.				13	7	11		T	.0
Louisville	525	188	234	29.53	30.11	+.03	58.4	−.9	79	20	67	31	27	50	28	52	48	74	3.25	+.6	10	7,012	s.	38	w.	6	12	7	12	5.1	.0	.0
Evansville	431	76	116	29.62	30.09	+.01	59.6	+.2	84	8	68	34	27	51	27	52	48	73	4.02	+1.2	12	6,275	s.	31	s.	31	9	11	11	5.7	.0	.0
Indianapolis	822	194	230	29.20	30.09	+.02	56.0	+.3	80	20	65	26	27	47	29	49	44	72	3.29	+.5	12	7,402	s.	28	n.	26	13	4	14	5.5	.0	.0
Terre Haute	575	63	149	29.45	30.07		57.0		82	20	66	28	27	47	30	50	46	77	5.91	+3.2	13	6,619	s.	29	n.	26	12	7	12	5.4	.0	.0
Cincinnati	627	11	51	29.42	30.11	+.03	56.6	+.9	80	15	66	26	28	47	33	50	47	80	4.45	+1.9	11	4,847	s.	24	sw.	29	9	8	14	6.2	.0	.0
Columbus	822	90	210	29.22	30.10	+.02	55.5	+.3	78	15	64	29	28	47	29	50	46	76	3.41	+1.0	15	6,539	s.	34	sw.	29	8	10	13	5.9	.0	.0
Dayton	900	58	153	29.12	30.09		55.6	+.6	77	20	64	28	28	47	30				4.08	+1.5	15	5,788	sw.	27	sw.	29	10	9	12	5.5	.0	.0
Elkins	1,947	59	78	28.08	30.15	+.05	53.6	+1.3	80	20	65	23	31	42	45	47	45	83	4.34	+1.4	12	4,074	w.	22	sw.	26	8	8	15	6.4	T	.0
Parkersburg	637	77	84	29.48	30.14	+.06	57.0	+.9	83	6	67	27	28	47	37	51	48	80	3.44	+1.0	11	4,211	se.	21	nw.	30	10	10	11	5.5	.0	.0
Pittsburgh [1]	1273	39	54	28.72	30.08	.00	54.4	−1.3	78	6	63	27	27	45	35	48	44	77	4.05	+1.5	14	7,465	sw.	34	nw.	30	8	12	11	6.0	T	.0
Lower Lake Region							**52.2**	**+0.1**										**75**	**2.84**	**0.0**										**6.4**		
Buffalo	768	243	280	29.21	30.05	0.00	51.6	−0.3	76	5	58	24	27	45	28	47	43	78	2.90	−0.4	11	11,348	sw.	56	sw.	29	3	12	16	6.6	T	.0
Canton	448	10	61	29.53	30.01		47.7	+.5	75	21	57	14	27	38	36	43	39	79	4.31	+1.3	17	6,586	sw.	32	w.	12	3	15	13	6.7	1.5	.0
Ithaca	836	77	100	29.15	30.07		51.2	+.1	78	20	61	23	27	42	36	45	41	73	3.41	+.4	14	7,332	nw.	31	nw.	30	10	6	15	6.0	T	.0
Oswego	335	71	85	29.67	30.04	−.01	51.3	+.1	76	21	59	23	27	44	26	46	41	73	3.21	−.1	15	7,137	s.	33	n.	26	6	9	16	7.0	T	.0
Rochester	523	86	102	29.49	30.06	+.01	52.4	+.9	79	20	61	26	28	44	29	46	41	70	2.31	−.3	14	6,174	sw.	34	w.	12	5	6	20	7.5	T	.0
Syracuse	596	65	79	29.41	30.05	−.01	53.2	+1.6	80	21	62	23	27	45	28				3.44	+.6	16	5,956	s.	26	w.	12	7	8	16	6.7	T	.0
Erie	714	130	166	29.29	30.06	+.01	53.6	+.2	78	20	61	27	28	46	26	48	44	76	2.86	−.8	14	10,120	s.	37	sw.	29	7	12	12	6.1	T	.0
Cleveland	762	267	318	29.24	30.07	+.01	54.2	+.6	77	20	61	31	28	47	27	48	43	70	1.78	−1.0	10	11,376	s.	54	sw.	6	8	8	15	6.2	T	.0
Sandusky	629	5	67	29.40	30.09	+.03	54.0	−.3	79	20	63	27	28	45	32				2.55	+.1	10	6,933	sw.	27	nw.	30	3	18	10	6.6	T	.0
Toledo	628	79	87	29.40	30.08	+.03	52.8	−.6	78	20	61	26	27	44	30	47	43	75	2.17	−.2	10	6,819	sw.	28	w.	29	10	10	11	5.5	T	.0
Fort Wayne	857	69	84	29.15	30.08		53.1	−.4	78	20	62	25	27	44	31	47	44	79	2.87	+.3	10	6,363	s.	24	w.	29	10	5	16	6.1	.0	.0
Detroit [1]	626	5	78	29.38	30.07	+.02	51.2	−1.3	77	20	60	25	27	42	28	46	42	78	2.33	.0	14	7,503	sw.	34	nw.	29	8	7	16	6.4	.3	.0
Upper Lake Region							**46.0**	**−2.5**										**77**	**2.69**	**0.0**										**6.8**		
Alpena	609	13	89	29.35	30.02	−.01	44.5	−2.6	76	8	52	20	27	37	36	41	37	80	3.32	+.6	13	8,198	nw.	37	nw.	11	6	14	11	6.3	T	.0
Escanaba	612	54	60	29.35	30.02	+.01	43.1	−2.9	66	16	51	18	23	36	28	39	35	76	2.17	−.5	9	8,120	sw.	38	n.	10	5	6	20	7.3	T	.0
Grand Rapids	707	70	244	29.26	30.04	.00	50.2	−1.0	77	19	59	25	27	42	33	46	43	81	2.77	.0	14	8,792	s.	37	sw.	19	6	10	15	6.9	.8	.0
Lansing	878	5	90	29.10	30.06		48.1	−2.2	73	5	57	19	27	39	32	44	41	84	2.24	−.2	15	6,480	s.	27	w.	29	8	11	12	6.1	.5	.0
Ludington	637	5	54	29.32	30.02		48.3	−1.4	73	6	56	27	23	41	24	44			3.29	+.4	9		s.				9	10	12		1.5	.0
Marquette	734	77	111	29.19	30.00	−.01	42.8	−3.9	75	9	50	23	26	36	27	38	35	77	1.94	−.8	16	7,852	w.	42	s.	30	3	10	18	7.5	1.5	.0
Sault Sainte Marie	614	11	52	29.32	30.02	+.01	40.8	−3.8	68	6	48	18	26	34	26	38	35	81	3.79	.0	21	6,314	nw.	38	nw.	11	6	3	22	7.6	2.0	.0
Chicago	673	7	131	29.32	30.05	+.01	53.6	−.4	81	19	61	31	28	46	32	48	43	73	3.00	+.5	10	7,679	s.	30	n.	25	12	4	15	5.7	T	.0
Green Bay	617	109	141	29.34	30.01	−.01	45.9	−2.6	73	8	54	21	23	38	28	41	36	74	2.04	−.5	11	8,559	s.	38	ne.	20	8	7	16	6.5	2.5	.0
Milwaukee	681	97	221	29.29	30.03	.00	49.8	−1.3	76	20	57	28	23	42	26	44	40	71	3.77	+1.4	10	9,571	w.	34	w.	29	8	4	19	6.9	.0	.0
Duluth	1,133	5	47	28.76	30.00	.00	39.2	−4.9	76	8	49	9	22	30	33	34	30	75	1.28	−1.0	7	9,422	nw.	41	nw.	29	6	12	13	6.7	7.0	.0
North Dakota							**42.4**	**−1.4**										**62**	**0.26**	**−0.9**										**5.0**		
Moorhead, Minn.	940	50	58	29.00	30.04	+.04	41.6	−2.9	84	8	54	4	26	29	42	35	27	63	.36	−1.3	4	6,984	n.	25	s.	30	7	10	14	6.1	1.9	.0
Bismarck	1,674	8	57	28.24	30.05	+.06	43.8	−1.1	89	8	57	8	22	30	50	35	27	58	.14	−.8	3	6,876	nw.	25	w.	28	15	10	6	4.3	.8	.0
Devils Lake	1,478	11	44	28.44	30.04	+.05	39.6	−2.8	86	8	53	4	22	26	43	33	27	69	.25	−1.0	4	7,485	nw.	33	nw.	28	8	12	11	5.7	.7	T
Grand Forks	833	12	67				39.0		85	8	52	1	22	26	43	32			.23		5		nw.	29	nw.	9	4	19	8		1.7	.0
Williston	1,878	42	50	28.04	30.04	+.06	44.4	+1.0	81	8	56	12	22	32	43	35	27	60	.29	−.6	5	6,305	sw.	30	nw.	28	16	7	8	4.1	2.1	T
Upper Mississippi Valley							**52.6**	**−0.8**										**75**	**2.37**	**−0.1**										**5.5**		
Minneapolis	919	105	208	29.02	30.02	+.01	46.4	−2.5	75	8	56	17	23	37	36	39	32	63	.66	−1.4	4	8,763	w.	34	n.	20	9	6	16	5.9	.1	.0
La Crosse	714	11	48	29.25	30.03	+.01	47.4	−2.9	76	15	57	20	23	38	32	42	38	78	2.77	+.4	7	4,546	s.	21	nw.	29	13	4	14	5.6	.0	.0
Madison	974	70	78	28.97	30.04	+.01	48.0	−2.3	76	20	56	24	27	40	35	43	39	77	2.47	.0	9	6,404	s.	25	n.	26	12	3	16	5.8	.0	.0
Charles City	1,015	10	51	28.96	30.05	+.03	47.2	−1.4	75	15	57	19	23	37	34	41	38	77	1.58	−.8	7	5,423	n.	22	nw.	29	12	7	12	5.0	.0	.0
Davenport	606	66	161	29.38	30.05	+.01	53.8	+.1	82	20	62	28	27	45	28	47	43	75	2.09	−.3	8	6,916	sw.	31	sw.	20	9	9	13	5.7	T	.0
Des Moines	861	5	99	29.13	30.05	+.02	52.2	−1.2	82	20	62	23	27	43	39	46	42	73	.93	−1.6	6	7,238	s.	27	nw.	9	11	10	10	5.0	.0	.0
Dubuque	700	60	79	29.28	30.04	.00	50.0	−1.9	81	20	59	22	27	41	35	44	40	75	3.64	+1.2	10	4,619	s.	20	n.	25	10	6	15	6.0	.0	.0
Keokuk	614	64	78	29.40	30.05	.00	56.0	+.6	83	20	65	29	27	47	29	49	44	71	1.80	−.5	7	5,827	sw.	23	s.	31	8	11	12	5.9	.0	.0
Cairo	358	87	93	29.70	30.08	+.01	60.0	−.4	81	5	69	35	27	51	28	53	50	78	3.81	+1.0	9	5,806	s.	24	n.	26	11	6	14	5.6	.0	.0
Peoria	609	11	45	29.40	30.07	+.02	54.2	+2.2	82	20	64	27	23	44	32	48	45	82	3.35	+1.1	9	4,528	s.	18	w.	29	9	11	11	5.6	T	.0
Springfield, Ill.	636	5	191	29.39	30.07	+.02	56.6	+.8	83	20	66	30	27	48	31	50	46	75	2.54	.0	11	8,120	s.	28	n.	25	11	5	15	5.4	T	.0
St. Louis	568	179	303	29.46	30.06	.00	58.8	.0	83	19	67	32	27	50	29	51	47	71	2.79	+.1	9	8,823	sw.	40	sw.	31	15	6	10	4.6	T	.0
Missouri Valley							**53.1**	**−0.9**										**65**	**1.57**	**−0.6**										**4.5**		
Columbia, Mo.	784	6	84	29.22	30.06	+.01	56.5	−.1	82	19	66	30	27	47	31				2.09	−.5	9	5,900	s.	26	sw.	31	11	9	11	5.1	.0	.0
Kansas City [1]	750	32	45	29.24	30.06	+.02	57.2	−.5	84	18	66	29	23	48	34	50	45	70	2.01	−.9	8	7,593	sw.	35	n.	25	14	6	11	5.0	.0	.0
St. Joseph	967	11	49	29.01	30.05		55.6		84	19	66	26	23	46	38	48	43	71	2.48	−.2	9	6,106	s.	27	n.	25	15	7	9	4.3	.0	.0
Springfield, Mo.	1,324	98	104	28.67	30.08	+.03	56.9	−1.3	80	19	65	33	27	49	29	50	46	75	5.27	+2.2	10	7,106	s.	26	w.	6	14	6	11	4.7	T	.0
Iola	984	11	50																													
Topeka	987	65	87	28.99	30.05		56.0	−1.0	85	5	66	28	23	46	36	49	44	70	.86	−1.6	5	7,090	s.	27	sw.	20	16	8	7	4.2	.0	.0
Lincoln	1,189	11	81	28.77	30.04	+.01	53.5	−.7	85	18	65	23	23	42	38	45	38	62	.19	−1.7	2	7,712	s.	31	n.	25	17	6	8	4.1	T	.0
Omaha [1]	982	31	44	28.99	30.05	+.02	52.2	−2.1	84	18	64	23	27	40	36	45	39	66	1.07	−1.1	3	7,810	n.	34	n.	9	15	8	8	4.2	.0	.0
Valentine	2,598	47	54	27.35	30.10	+.09	47.7	−1.6	83	18	62	9	26	34	47	38	29	57	.35	−.8	4	6,518	w.	28	ne.	20	14	8	9	4.7	.9	.0
Sioux City	1,138	64	106	28.82	30.04	+.02	51.1	+.2	83	18	63	21	26	40	39	42	35	60	.99	−.8	5	7,083	s.	33	s.	30	13	11	7	4.5	.2	.0
Huron	1,307	59	74	28.64	30.06	+.05	46.8	−.9	83	18	60	10	26	33	45	38	29	58	.35	−.9	2	7,565	n.	31	s.	30	15	13	3	4.0	.8	.0
Northern Slope							**46.7**	**+1.6**										**61**	**.98**	**.0**										**4.7**		
Havre	2,505	11	67	27.41	30.06	+.08	47.9	+3.4	85	7	61	15	22	35	52	38	28	54	.73	+.1	5	7,409	sw.	32	w.	14	13	8	10	4.8	2.0	.4
Helena	4,124	85	111	25.91	30.13	+.10	47.6	+2.7	78	11	59	16	31	36	37	38	30	56	.84	.0	7	5,100	sw.	24	nw.	14	11	10	10	5.1	5.2	4.5
Missoula	3,263	80	91				49.2	+4.4	77	8	63	23	31	36	41				.47	−.7	6	4,178	se.	31	e.	31	16	8	7	3.7	.2	.2
Kalispell	2,973	48	56		30.12	+.11	45.2	+1.7	72	8	58	19	31	32	36			73	1.00	−.1	4	4,293	nw	21	ne.	19	15	8	8		5.0	1.0
Miles City	2,371	48	55	27.53	30.11	+.11	48.5	+2.0	83	8	62	24	21	36	41	39	30	57	.57	−.3	6	5,004	s.	25	nw	16	14	10	7	4.8	.6	T
Rapid City	3,259	50	58	26.68	30.12	+.11	48.8	+.3	84	8	61	10	22	37	40	39	30	55	.81	−.1	6	5,992	w.	27	nw.	10	14	11	6	4.5	4.9	.0
Cheyenne [1]	6,144	5	44	24.03	30.10	+.09	44.4	−.4	77	12	58	17	21	31	47	35	28	64	.68	−.3	9	8,642	nw.	37	nw.	18	11	10	10	5.3	5.8	.0
Lander	5,372	60	68	24.73	30.13	+.09	44.2	+.7	77	8	57	11	22	31	42	37	30	63	2.75	+1.4	7	3,303	sw.	22	n.	5	12	8	11	5.1	6.4	.0
Sheridan	3,790	10	47	26.18	30.11		46.3		83	11	61	12	22	31	49	38	32	68	1.82	+.8	9	3,810	nw.	25	nw.	14	13	8	10	4.7	2.2	.0
Yellowstone Park	6,241	12	46	23.98	30.20	+.18	41.6	+1.9	74	8	55	17	22	28	41	33	25	58	.67	−.6	6	5,208	sw.	25	sw.	30	14	9	8	4.5	.5	T
North Platte	2,821	11	51	27.13	30.08	+.06	49.5	−.2	87	12	65	14	22	34	46	39	32	62	.41	−.7	5	5,585	w.	26	n.	9	14	10	7	4.4	3.0	.0

[1] Observations taken at airport.

TABLE 1.—*Climatological data for Weather Bureau stations, August 1936*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to means of 24 hours.	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	F.	Ft.	In.	In.	In.	° F.	° F.	°F.		°F.	° F.		°F.	° F.	° F.	° F.	%	In.	In.		Miles								0-10	In.	In.
Middle Slope							54.0	−1.9										66	1.71	0.0										4.6		
Denver	5,292	106	113	24.80	30.09	+0.08	49.8	−1.4	81	18	61	21	22	38	38	40	33	62	2.04	+1.0	9	5,339	s.	30	nw.	5	11	12	8	5.0	7.3	0.0
Pueblo	4,685	80	86	25.36	30.06	+.07	51.6	−.4	85	12	64	25	24	39	42	41	33	57	.76	+.1	6	4,812	nw.	21	nw.	5	13	9	9	4.8	1.1	.0
Concordia	1,392	50	58	28.61	30.10	+.07	54.2	−1.7	84	5	65	23	26	44	37	46	40	67	.75	−1.2	5	6,480	sw.	26	s.	30	15	11	5	4.2	T	.0
Dodge City	2,509	10	86	27.47	30.09	+.07	53.8	−2.3	85	19	66	23	27	42	40	45	40	69	1.00	−.3	8	8,827	s.	37	ne.	6	14	11	6	4.1	.9	.0
Wichita	1,358	85	93	28.62	30.06	+.03	56.1	−2.5	82	5	65	27	27	47	34	49	44	68	3.77	+1.2	5	8,511	sw.	32	sw.	20	16	7	8	4.4	.0	.0
Oklahoma City	1,214	10	47	28.77	30.06	+.03	58.6	−2.9	87	19	68	29	27	49	29	52	48	75	1.93	−.9	6	7,252	s.	25	s.	20	14	4	13	4.9	.0	.0
Southern Slope							60.6	−2.6										68	1.28	−0.6										4.1		
Abilene	1,738	10	52	28.26	30.07	+.06	62.1	−3.3	91	19	73	35	23	51	35	53	48	71	2.42	−.1	5	6,725	s.	27	s.	31	18	3	10	3.6	.0	.0
Amarillo	3,676	10	49	26.34	30.07	+.07	56.5	−1.2	89	19	68	29	26	44	36	46	40	65	.82	−.8	5	6,646	s.	21	nw.	6	16	7	8	4.3	2.3	.0
Del Rio	960	63	71	29.03	30.02	+.04	65.8	−4.2	95	18	76	42	23	55	39	57	53	73	1.57	−.3	11	6,154	se.	29	n.	6	17	5	9	4.2	.0	.0
Roswell	3,566	75	85	26.44	30.04	+.08	57.9	−1.6	87	12	71	33	22	45	42	48	41	63	.29	−1.1	4	5,530	s.	25	ne.	6	15	8	8	4.4	.1	.0
Southern Plateau							60.2	+0.7										54	0.70	0.0										3.0		
El Paso	3,778	82	101	26.23	29.99	+.07	63.4	−.1	86	12	75	43	23	52	35	51	42	53	.32	−.5	3	5,470	e.	23	ne.	6	19	7	5	3.0	.0	.0
Albuquerque[1]	4,972	5	39	25.11	30.00	------	55.2	−1.4	80	3	70	34	27	41	40	44	37	60	.17	−.6	6	5,414	n.	36	nw.	6	16	11	4	3.9	.0	.0
Santa Fe	7,013	38	53	23.32	30.02	+.06	50.0	−.4	73	12	61	29	23	39	34	41	35	65	.83	−.4	7	3,935	s.	17	n.	8	13	10	8	4.3	3.0	.0
Flagstaff	6,907	10	59	23.39	29.94	+.02	47.5	+2.8	79	10	62	25	27	33	45	38	----	60	2.37	------	9	6,026	sw.	29	sw.	15	10	12	9	----	.0	.0
Phoenix	1,108	10	107	28.74	29.88	.00	73.2	+2.6	100	11	87	48	26	59	42	56	43	41	.13	−.3	1	4,053	e.	23	sw.	15	20	6	5	2.5	.0	.0
Yuma	141	9	54	29.73	29.88	+.01	74.0	+.7	104	10	89	51	25	59	41	58	46	44	T	−.3	0	3,937	w.	19	n.	23	26	4	1	1.3	.0	.0
Independence	3,957	5	26	26.00	30.02	+.07	58.0	+.5	86	10	73	35	25	43	42	45	29	----	2.72	+2.4	4	------	n.	----	------	---	24	3	4	----	.0	.0
Middle Plateau							52.2	+1.7										50	1.22	+0.3										3.4		
Reno	4,527	61	76	25.53	30.03	+.04	53.9	+3.1	84	10	69	28	28	39	43	42	30	46	.20	−.2	3	3,993	w.	23	ne.	16	21	7	3	2.7	.0	.0
Tonopah	6,090	12	20	------	------	------	52.6	------	78	10	61	35	23	45	21	41	28	45	1.60	------	6	------	nw.	----	------	---						
Winnemucca	4,344	18	56	25.69	30.09	+.04	51.0	+2.7	87	10	69	20	29	32	54	39	27	48	.47	−.2	2	5,131	ne.	25	ne.	16	23	4	4	2.6	.0	.0
Modena	5,473	10	43	24.66	30.00	+.04	48.8	+.8	81	11	64	25	24	34	46	39	30	58	2.73	+2.0	9	6,299	w.	25	e.	15	17	4	10	4.2	T	.0
Salt Lake City[1]	4,240	32	46	25.79	30.04	+.03	52.4	−.1	82	11	65	27	23	39	41	42	34	55	1.69	+.2	4	6,112	se.	34	sw.	2	17	7	7	3.7	.0	.0
Grand Junction	4,602	60	68	25.43	30.01	+.02	55.0	+2.2	81	9	68	30	25	42	37	43	32	50	.52	−.4	5	4,178	se.	26	w.	19	17	7	7	3.6	.0	.0
Northern Plateau							54.0	+4.3										50	0.17	−0.9										2.8		
Baker	3,471	48	53	26.56	30.15	+.07	50.8	+4.2	82	10	67	24	22	35	46	41	30	50	.03	−.9	1	4,766	se.	23	n.	22	21	7	3	2.8	T	.0
Boise	2,739	79	87	27.25	30.11	+.05	55.0	+3.9	85	10	69	30	22	41	36	44	32	46	.04	−1.2	2	3,563	se.	18	se.	29	18	12	1	2.7	.0	.0
Pocatello	4,477	60	68	25.55	30.08	+.04	50.9	+2.5	83	11	65	25	23	37	40	40	29	48	.53	−.6	3	5,328	se.	21	s.	2	19	7	5	3.3	T	.0
Spokane	1,929	101	110	28.06	30.12	+.06	52.2	+3.9	80	8	65	29	28	39	41	44	35	57	.28	−.9	4	3,269	s.	18	sw.	4	18	10	3	3.2	T	T
Walla Walla	991	57	65	29.03	30.10	+.03	58.2	+4.7	83	8	70	33	21	47	34	48	36	46	.03	−1.5	1	3,546	s.	17	w.	4	23	4	4	2.0	.0	.0
Yakima	1,076	58	67	28.96	30.11	------	56.7	+6.5	84	9	71	31	22	42	40	46	37	52	.10	−.5	1	3,408	nw.	21	sw.	14	18	11	2	2.6	.0	.0
North Pacific Coast Region							55.6	+3.2										74	0.98	−2.9										5.0		
North Head	211	11	56	29.91	30.14	+.09	55.2	+2.3	87	9	60	42	28	50	33	52	49	87	.95	−4.1	5	7,681	n.	33	s.	4	13	5	13	5.4	.0	.0
Seattle	125	90	321	30.00	30.13	+.08	55.9	+4.5	75	10	62	42	23	50	23	52	49	79	.88	−2.0	6	5,033	n.	27	s.	13	6	10	15	6.7	.0	.0
Tatoosh Island	86	10	54	30.04	30.14	+.13	51.6	+1.7	66	9	55	40	31	48	15	50	48	90	3.54	−4.6	7	8,671	e.	42	e.	9	9	6	16	6.4	.0	.0
Medford[1]	1,329	29	58	28.66	30.06	------	58.3	------	97	9	78	28	29	39	56	47	35	51	T	−1.3	0	------	s.	----	------	---	23	4	4	2.3	.0	.0
Portland, Oreg	153	68	106	29.95	30.11	+.05	58.6	+4.4	88	10	68	36	29	49	31	52	47	70	.44	−2.7	5	3,943	nw.	23	ne.	16	8	16	7	5.1	.0	.0
Roseburg	510	45	76	29.54	30.10	+.02	56.9	+3.0	92	7	72	30	29	41	49	49	43	66	.05	−2.6	2	2,512	n.	19	n.	15	12	10	9	3.9	.0	.0
Middle Pacific Coast Region							63.2	+2.9										62	0.40	−1.2										3.5		
Eureka	62	73	89	29.99	30.06	.00	54.0	+.4	76	16	60	41	28	48	28	51	48	85	.49	−1.8	1	3,731	n.	22	n.	15	11	6	14	5.4	.0	.0
Redding	722	20	34	------	------	------	70.6	+6.3	99	8	82	42	31	59	35	53	34	32	.09	−2.0	1	6,341	nw.	26	n.	16	21	5	5	2.6	.0	.0
Sacramento	66	92	115	29.89	29.96	−.03	66.0	+3.1	94	8	79	46	25	53	37	54	44	52	.35	−.6	2	4,500	s.	31	n.	15	24	5	2	1.8	.0	.0
San Francisco	155	112	132	29.80	29.97	−.04	62.2	+1.7	86	8	70	50	27	54	32	54	51	78	.69	−.4	1	5,575	w.	24	w.	11	12	12	7	4.2	.0	.0
South Pacific Coast Region							66.7	+2.3										67	1.89	+1.3										3.7		
Fresno	327	97	105	29.60	29.95	−.01	67.6	+3.6	97	9	80	48	30	55	37	56	47	56	2.55	+2.0	5	3,611	nw.	18	sw.	30	20	7	4	2.8	.0	.0
Los Angeles	338	159	191	29.58	29.95	.00	67.4	+2.1	96	8	76	55	26	58	39	58	52	67	1.25	+.6	5	4,280	sw.	21	e.	16	18	5	8	3.5	.0	.0
San Diego	87	62	70	29.85	29.94	−.01	65.0	+1.3	85	7	71	54	27	59	28	60	56	78	1.86	+1.3	7	4,962	nw.	21	se.	16	13	11	7	4.7	.0	.0
West Indies																																
San Juan, P. R	82	9	54	29.86	29.94	------	79.2	−.6	87	19	84	73	11	75	12	----	----	----	6.37	+.5	24	7,382	e.	26	e.	6	6	22	3	4.8	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	------	[2] 29.82	.00	79.1	−.1	91	13	85	71	2	74	20	----	----	[2] 90	9.48	−.6	27	3,500	nw.	19	s.	7	0	6	25	8.8	.0	.0
Cristobal	36	6	97	------	[3] 29.83	.00	81.4	+1.6	90	3	87	74	29	76	15	76	75	[3] 85	11.36	−4.1	25	4,064	se.	26	w.	29	0	11	20	7.9	.0	.0
Alaska																																
Fairbanks	454	11	87	[3] 29.25	[3] 29.78	------	30.2	------	56	1	37	3	8	23	29	29	26	79	2.02	------	15	4,097	ne.	26	sw.	17	7	4	20	7.5	12.3	2.0
Juneau	80	96	116	[3] 29.89	[3] 29.98	------	46.9	------	60	11	51	29	31	43	13	46	44	88	18.71	------	27	5,694	s.	30	se.	5	2	3	26	9.1	T	.0
Hawaiian Islands																																
Honolulu	38	86	100	[3] 29.92	[3] 29.96	------	77.4	+.6	85	23	82	69	25	72	13	72	70	78	11.26	+9.7	14	5,479	e.	24	ne.	11	8	17	6	4.9	.0	.0

[1] Observations taken at airport.
[2] Observations taken bihourly.
[3] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, October 1936*

Station	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99				45.3		51.7	38.8	58	29	6.27		0.0
Sydney, Cape Breton Island	48	29.96	30.01	+0.05	47.9	+1.4	56.4	39.3	72	26	4.29	−0.40	.0
Halifax, Nova Scotia	88	29.80	29.91	−.09	48.9	+1.7	56.0	41.8	66	24	5.52	−.03	.0
Yarmouth, Nova Scotia	65	29.95	30.02	.00	48.9	+1.3	56.1	41.7	66	27	4.97	+.85	T
Charlottetown, Prince Edward Island	38	29.92	29.96	.00	46.4	−.1	53.6	39.2	69	23	4.64	−.26	.5
Chatham, New Brunswick	28	29.87	29.90	−.06	42.3	−.7	52.0	32.6	69	12	3.70	−.05	T
Father Point, Quebec	20												
Quebec, Quebec	296	29.60	29.93	−.07	43.0	+.6	49.4	36.7	65	21	6.21	+3.06	2.1
Doucet, Quebec	1,236				33.4		41.5	25.2	67	2	4.95		5.8
Montreal, Quebec	187												
Ottawa, Ontario	236	29.75	30.02	+.01	43.5	−.3	51.7	35.3	71	16	5.14	+2.59	2.7
Kingston, Ontario	285												
Toronto, Ontario	379	29.64	30.05	+.01	49.0	+2.4	56.8	41.2	73	21	2.45	+.09	.3
Cochrane, Ontario	930												
White River, Ontario	1,244	28.64	29.98	.00	32.6	−4.5	42.5	22.7	68	−4	3.09	+.74	5.2
London, Ontario	808												
Southampton, Ontario	656	29.30	30.02	.00	46.3	+.2	54.5	38.1	72	22	3.10	−.07	1.3
Parry Sound, Ontario	688												
Port Arthur, Ontario	644	29.37	30.10	+.12	35.3	−4.6	44.2	26.5	71	4	1.36	−1.20	.4
Winnipeg, Manitoba	760	29.16	30.02	+.04	35.4	−3.7	45.7	25.1	80	−5	1.00	−.70	9.8
Minnedosa, Manitoba	1,690												
Le Pas, Manitoba	860				32.2		40.8	23.6	67	−1	.58		4.8
Qu'Appelle, Saskatchewan	2,115	27.69	29.97	.00	37.8	−1.6	49.5	26.0	78	−4	.72	−.38	.5
Moose Jaw, Saskatchewan	1,759				41.6	−3.2	54.2	29.1	83	−2	.17		.3
Swift Current, Saskatchewan	2,392	27.43	29.97	.00	42.6	+.5	54.0	31.1	78	4	.60	−.28	1.7
Medicine Hat, Alberta	2,365	27.53	30.03	+.06	46.3		58.4	34.3	84	17	.60	+.02	4.4
Calgary, Alberta	3,540	26.37	30.07	+.12	45.1	+5.0	56.5	33.7	81	6	.67	+.19	5.2
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.43	30.03	+.06	36.3	−.8	44.6	28.1	73	6	1.01	+.18	6.6
Battleford, Saskatchewan	1,592	28.25	30.02	+.05	39.4	−.2	50.3	28.5	78	7	1.73	+1.28	7.2
Edmonton, Alberta	2,150	27.70	30.00	+.07	42.7	+1.6	53.8	31.6	76	8	1.21	+.51	9.2
Kamloops, British Columbia	1,262	28.83	30.15	+.19	48.7	+1.7	58.8	38.7	73	26	.24	−.37	.0
Victoria, British Columbia	230	29.89	30.15	+.14	53.4	+4.2	59.2	47.5	76	41	.96	−1.41	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20				52.6		57.8	47.3	67	40	4.16		.0
Prince Rupert, British Columbia	170												
St. Georges, Bermuda	158		30.08	+.06	76.2	+2.6	81	72	86	66	4.24	−2.07	.0

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Father Point, Quebec	20	29.97	29.99	+.01	50.7	+0.3	57.7	43.8	78	35	1.74	−1.39	.0
Montreal, Quebec	187	29.87	30.07	+.03	59.4	+1.0	67.2	51.6	84	37	2.44	−.86	.0
Port Arthur, Ontario	644	29.35	30.06	+.08	52.8	+.6	62.5	43.1	82	26	2.06	−1.42	.0
Minnedosa, Manitoba	1,690	28.11	29.91	−.03	53.8	+3.3	66.5	41.0	90	25	3.23	+1.87	.0
Kamloops, British Columbia	1,262	28.73	30.11	+.04	57.4	.0	69.3	45.6	87	34	1.26	+.41	.0
Estevan Point, British Columbia	20				54.6		60.2	48.9	67	38	4.05		.0
Prince Rupert, British Columbia	170						58.2		73		7.79		.0

TABLE 3.—*Severe local storms, October 1936*

(Compiled by Mary O. Souder from reports submitted by Weather Bureau officials)

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Spartanburg and adjoining counties, South Carolina.	Sept. 30–Oct. 1					Heavy rain and flood	See late reports for September.
Ardmore, Okla	6	4:20–4:50 p. m	[1] 3		$300,000	Hail	Roofs of practically all buildings in the main path of the storm damaged or destroyed; greenhouses wrecked, hundreds of windows broken and automobile tops damaged; small crop loss. Path 8 miles in length.
Rockville, Ind., vicinity of	6					Wind	Several farm buildings destroyed; 2 cows killed by falling timbers.
San Antonio, Tex	6					do	Maximum wind velocity, 50 miles from northwest, highest recorded at this station in October. Damage mostly to signs, trees, and wires.
Red Bank, Tenn	9	7 p. m			13,500	do	House completely demolished and roofs and porches of several others blown away; garage and outbuildings flattened; many large forest trees, wires, and poles down blocking traffic.
Columbia, S. C., vicinity of	9				1,000	Rain	2 small dams partially washed out.
Buffalo, N. Y., and vicinity	12					Wind	2 persons injured; considerable damage to plate glass windows, trees, and wires. In Niagara County hundreds of bushels of apples blown down.
Salt Lake City to Brigham City, Utah, and vicinity.	15–16	P. m			500,000	do	Roads blocked by fallen trees and poles. Heaviest individual damage when an unfinished warehouse in Ogden was blown down. Windows broken and 2 persons injured.
New York, N. Y., and vicinity [2]	17					Wind and rain	Wind reached 45 miles an hour in New York City. Electric feeder lines burned out in Brooklyn, causing darkness over a considerable area for a short time. In Amagansett, Long Island, a boy was injured by falling tree and several persons were hurt in automobile accidents caused by the storm. In Bayonne, N. J., a ferryboat broke from its moorings, tearing loose 2 barges and a motorboat before going aground.
Cleveland, Ohio, vicinity of	17	10 p. m		19	200,000	Wind	Sand barge sank during gale and all on board lost with the exception of 7 men who clung all night to overturned lifeboats.
Rhode Island and southern Massachusetts.[2]	17					Wind and rain	Rain fell in sheets and highways were made hazardous by blankets of leaves blown from trees; 8 persons injured; small crafts torn from their moorings; falling trees endangered motorists and pedestrians. Block Island left without boat service from the mainland.
Detroit, Mich	29	8:10 p. m			1,000	Line squall and rain	2 police officers injured when blown from their motorcycles; several plate-glass windows and small windows in homes blown in.
South Dakota (eastern two-thirds).	30					Dust storm	The following is quoted from the report of the W. B. Section Director: "The dust storm on the 30th was considered the worst of the season."
Minnesota (extreme western counties).	30					do	The following is quoted from the report of the W. B. Section Director: "The most severe dust storm of this year. * * *"
Marquette, Mich	30					Wind	Highest wind velocity recorded in October, 42 miles from the south, occurred during this storm. A scow loaded with a large boiler anchored in the harbor was rocked sufficiently to roll the boiler off and fill the scow with water. Several small motorboats sunk at their moorings; considerable damage to storm windows and street lights.
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Spartanburg and adjoining counties, S. C.	Sept. 30–Oct. 1				$186,000	Heavy rain and flood	Damage to roads and bridges, $36,000; crop loss, $150,000.
Eastern Shore, Md	18				102,110	Tropical hurricane	Loss to railroad property.

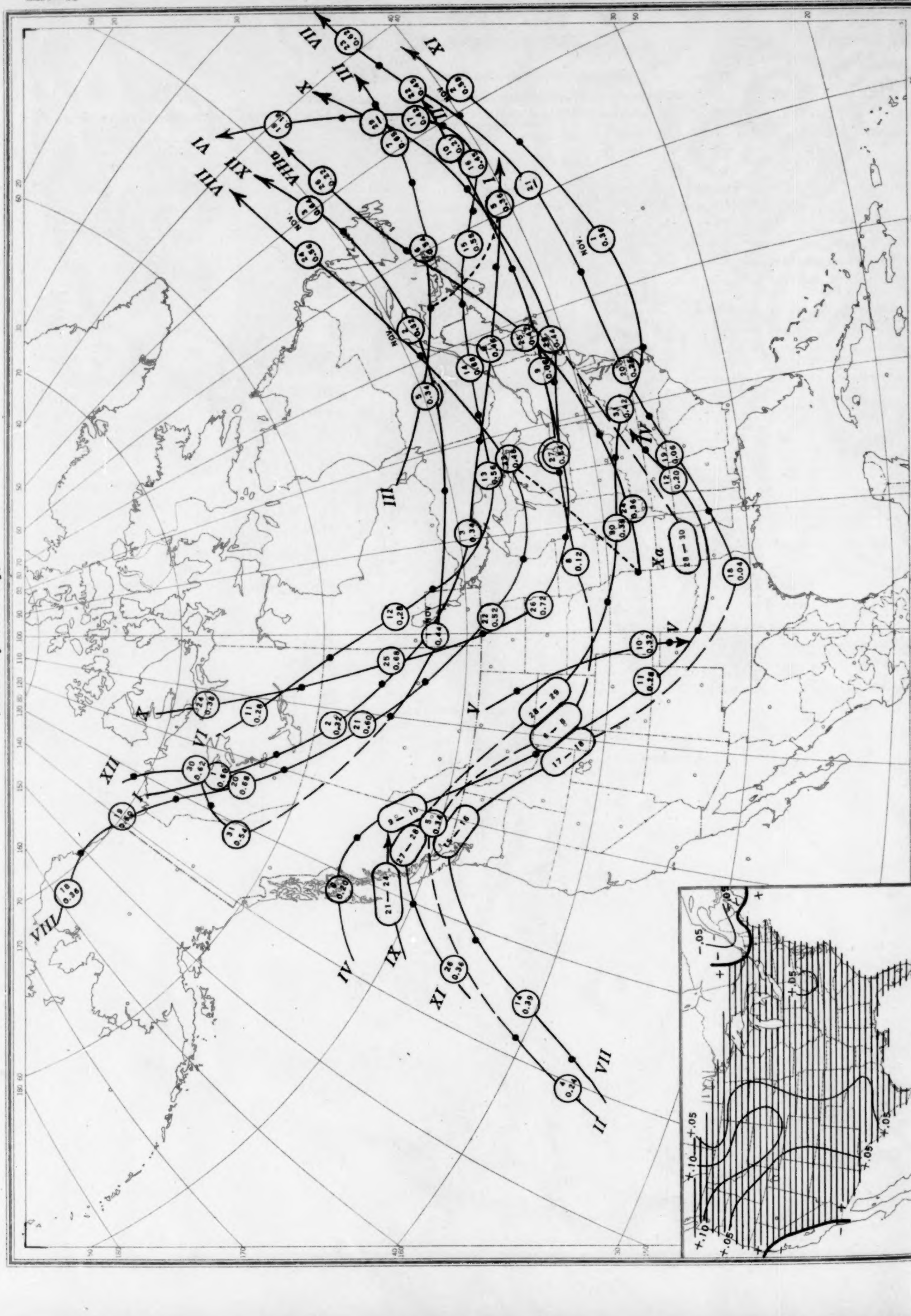
[1] Miles instead of yards.
[2] From press reports.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, October 1936

Chart I. Departure (°F.) of the Mean Temperature from the Normal, October 1936

Chart II. Tracks of Centers of Anticyclones, October 1936. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. P. Day)



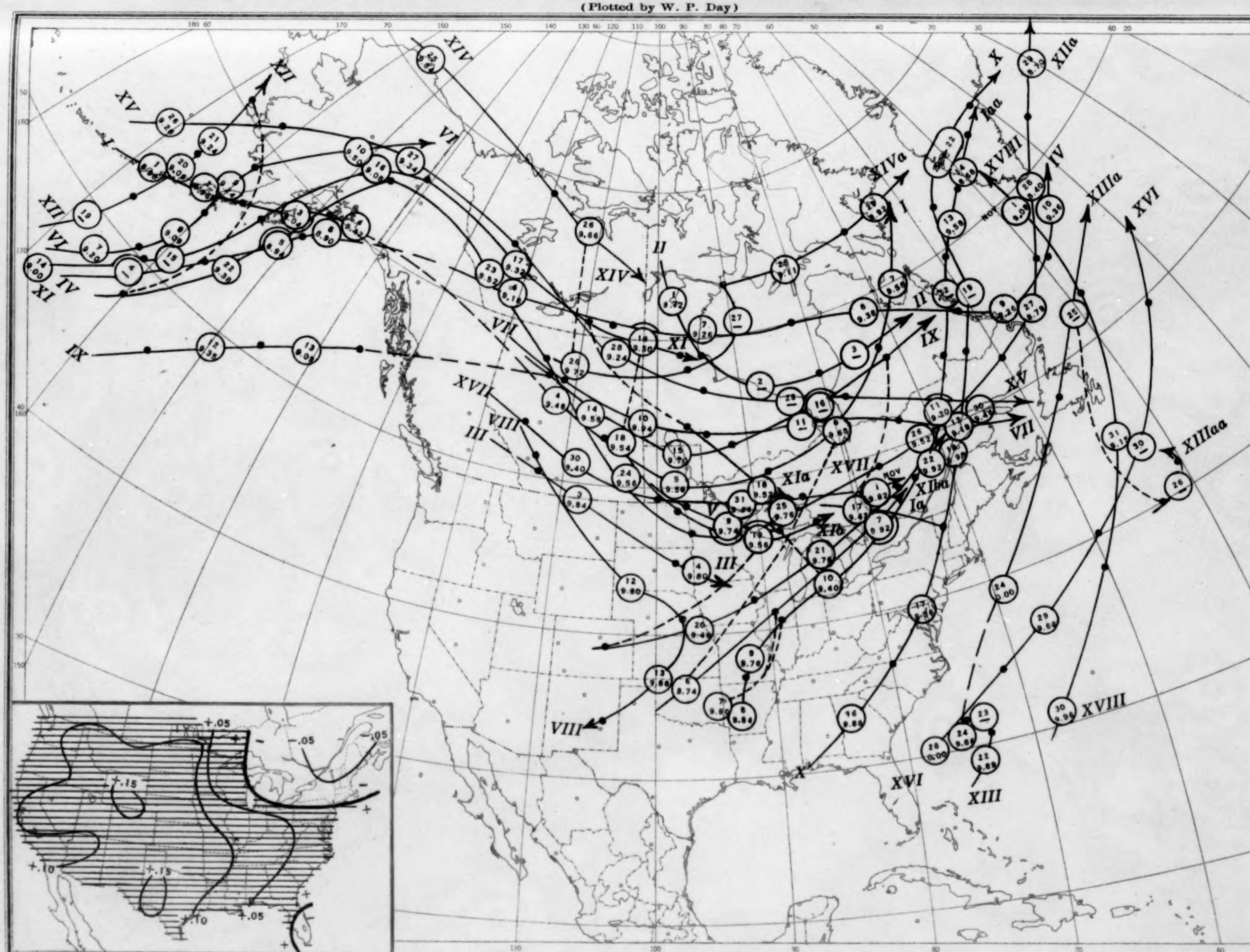
Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, October 1936. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, October 1936. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by W. P. Day)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, October 1936

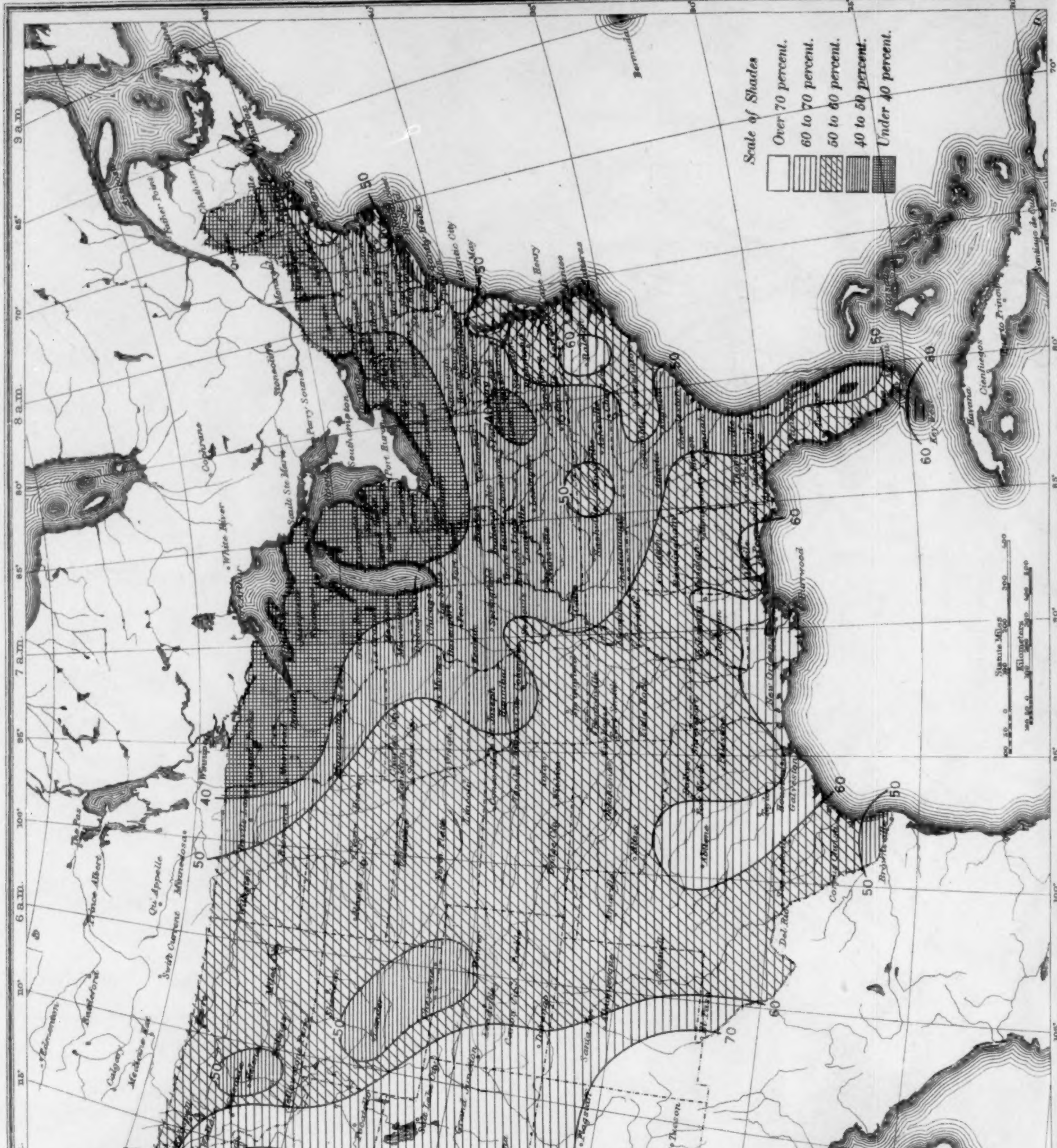


Chart V. Total Precipitation, Inches, October 1936. (Inset) Departure of Precipitation from Normal

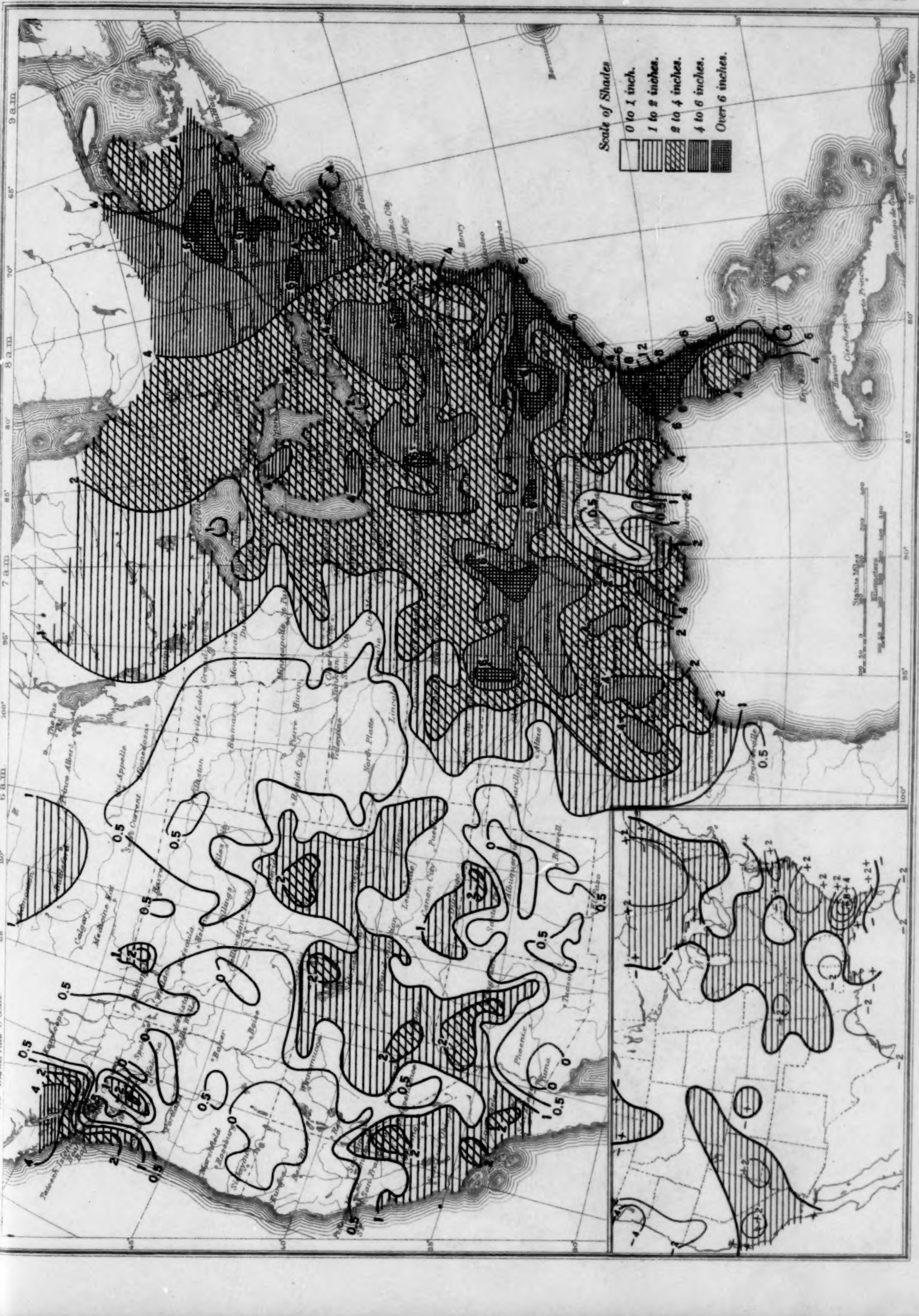
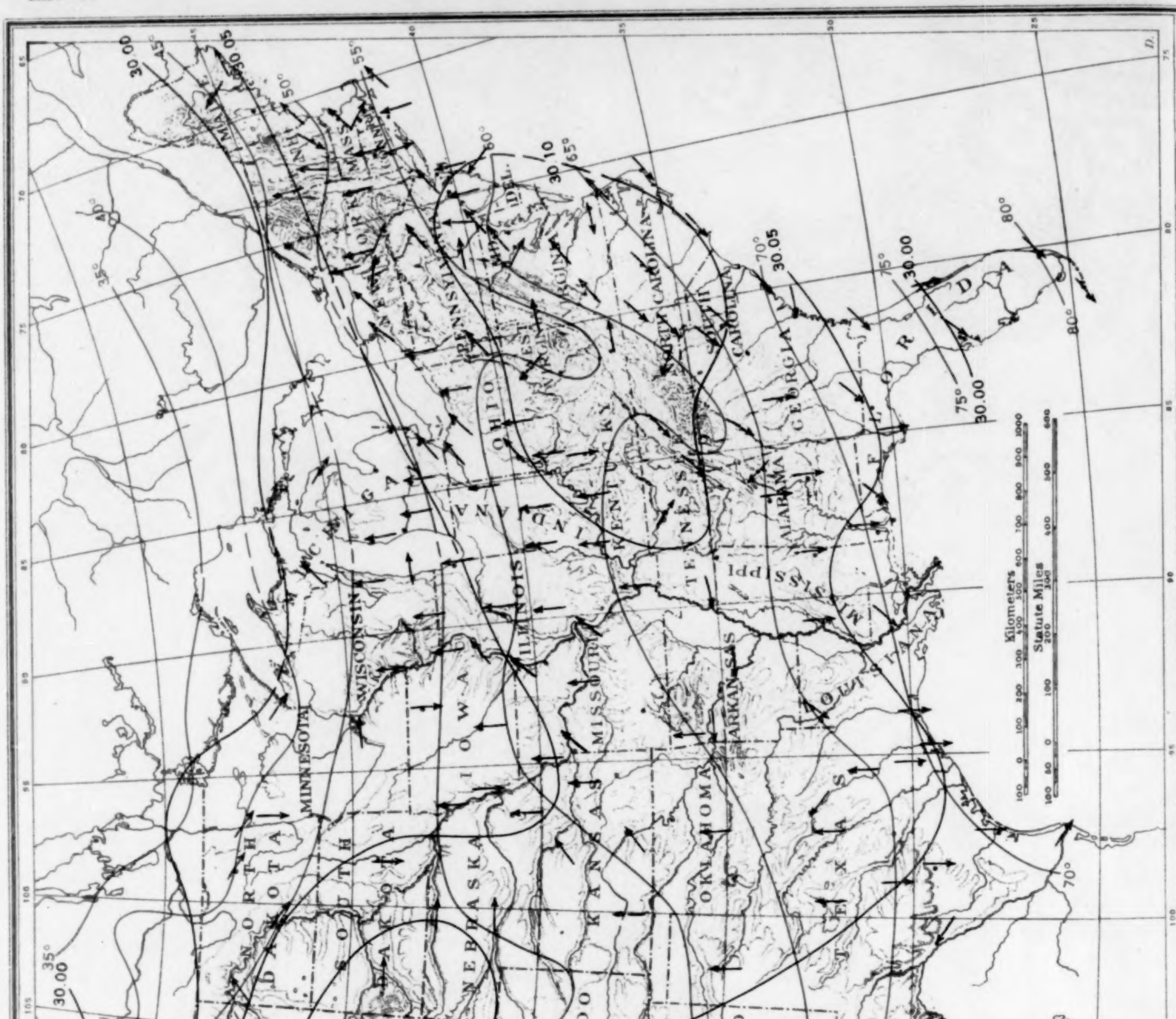


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, October 1936



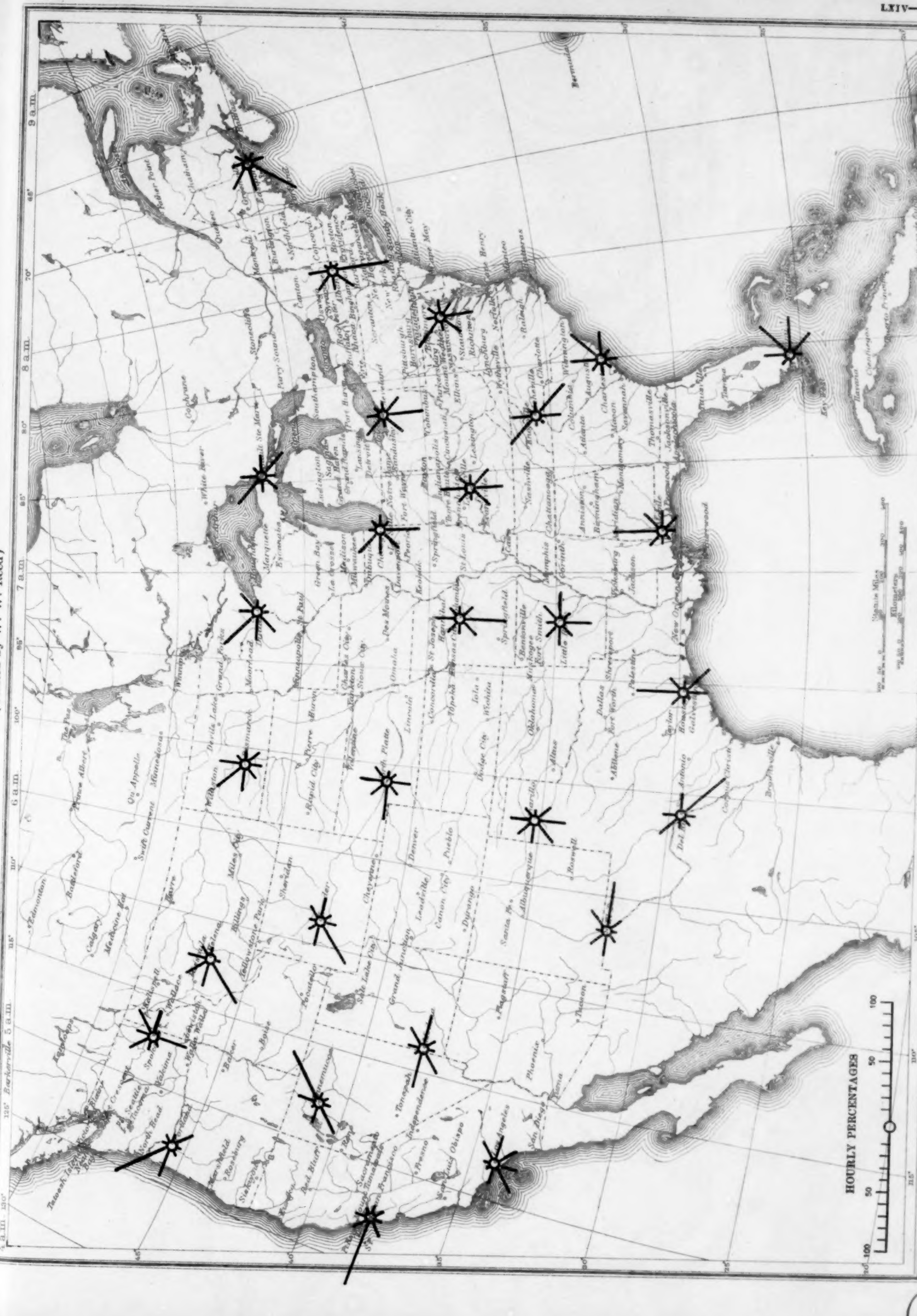


Chart VII. Wind Roses for Selected Stations, October 1936

(Plotted by W. W. Reed)

(Plotted from the Weather Bureau Northern Hemisphere Chart)

(Plotted from the Weather Bureau Northern Hemisphere Chart)

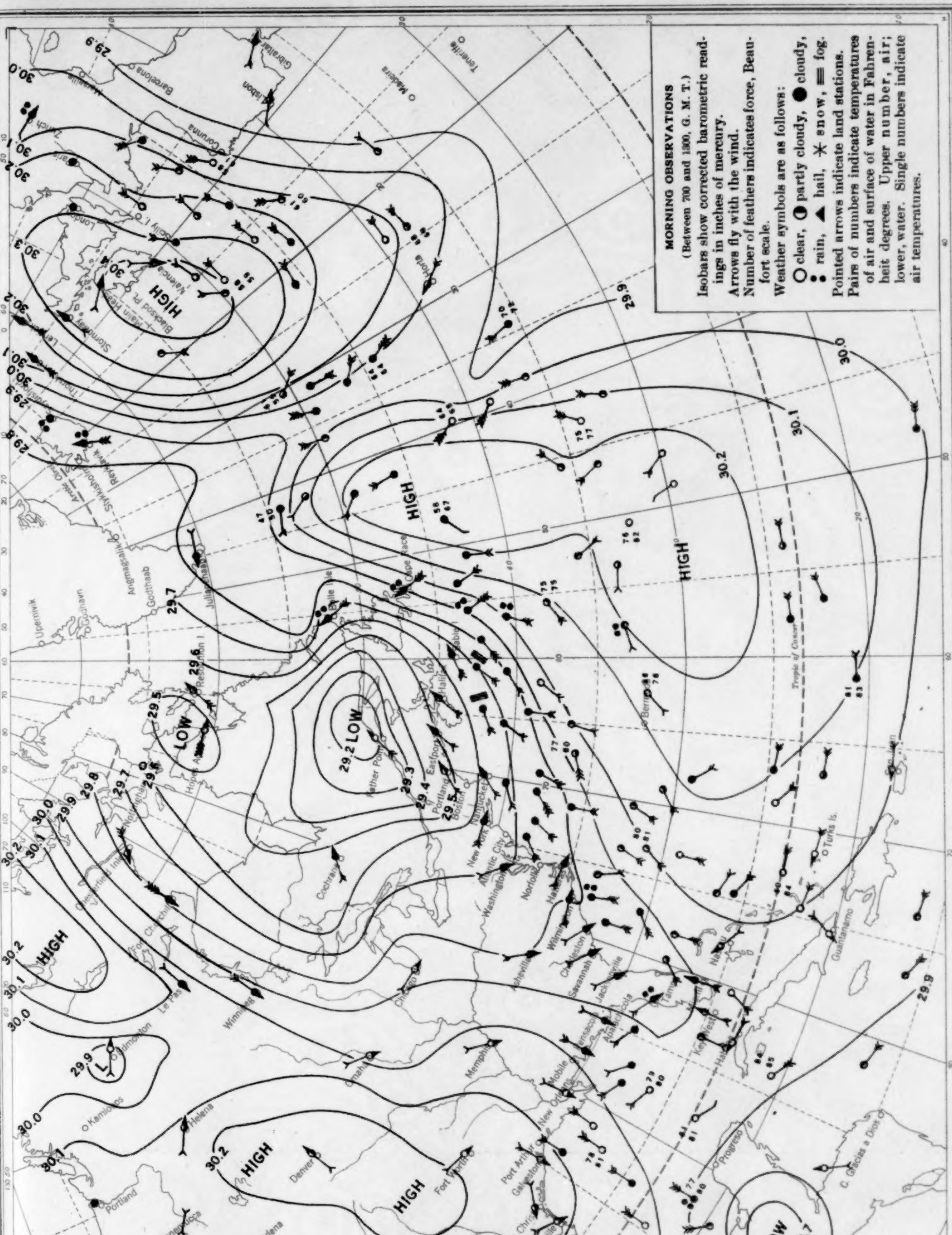


Chart X. Weather Map of North Atlantic Ocean, October 31, 1936

(Plotted from the Weather Bureau Northern Hemisphere Chart)